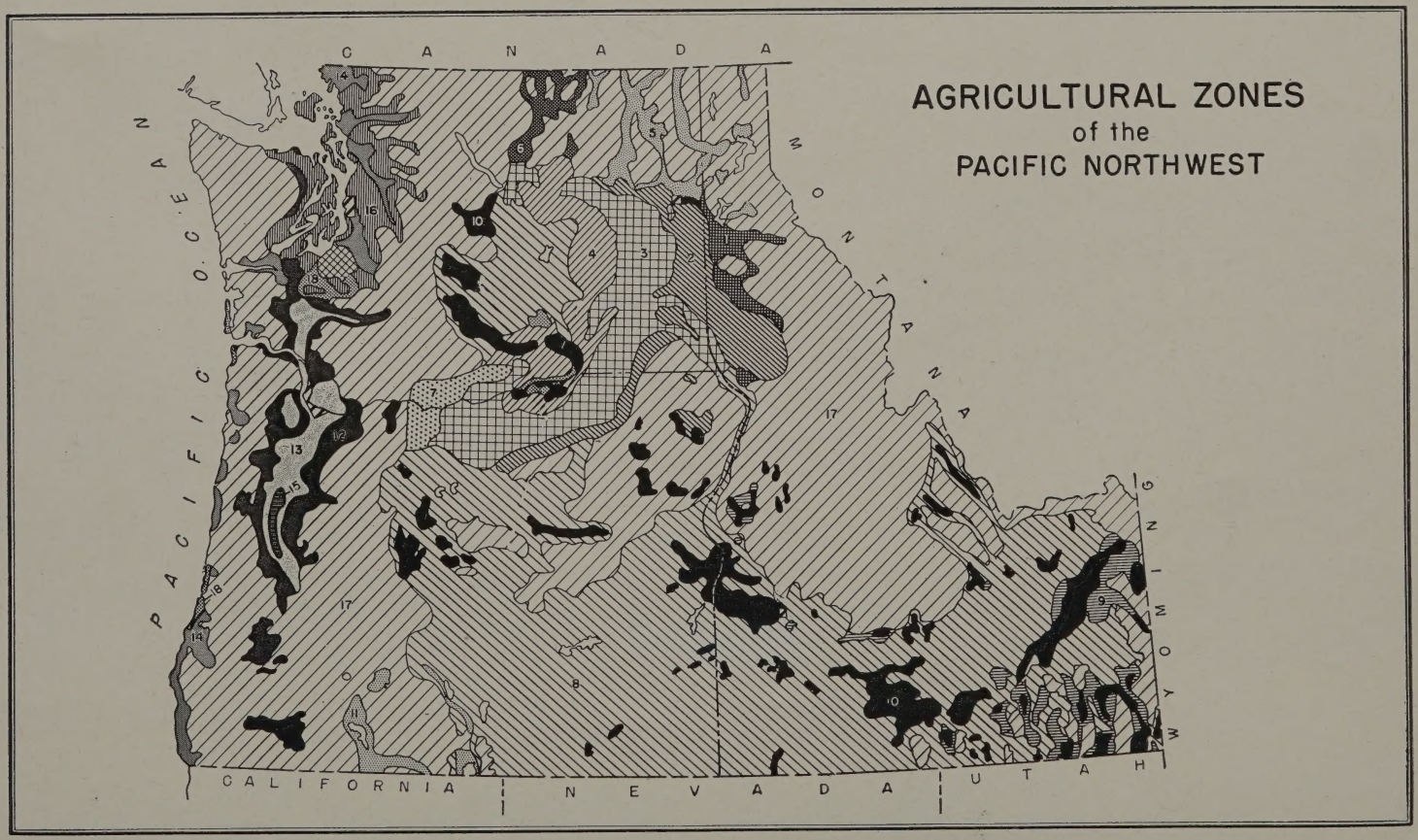


GRASSES and LEGUMES for SOIL CONSERVATION in the PACIFIC NORTHWEST



MISCELLANEOUS PUBLICATION No. 678

U. S. DEPARTMENT of AGRICULTURE


AGRICULTURAL ZONES
of the
PACIFIC NORTHWEST
C A N A D A
PACIFIC OCEAN
MONTANA
WYOMING
CALIFORNIA
N E V A D A
U T A H

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Legend for Agricultural Zones

1. Cut-over foothills area; residual granitic soils, erodible, low in fertility; hay and pasture crops predominate; rainfall 24 inches and over.
2. Palouse wheat-pea area; loessial soils, productive, erodible unless carefully managed; annual grain crops; rainfall 18–22 inches.
3. Wheat-fallow area; loessial soils, productive, erodible unless carefully managed, especially on long, steep slopes; cereal grain and summer-fallow; rainfall 12–18 inches.
4. Semiarid wheat-fallow area; glacial outwash and river terrace soils with some loessial deposits on surface, depth varies; wind erosion predominates; wheat and fallow with range in scabland channels; rainfall 8–12 inches.
5. Glaciated valleys; glacial outwash and river terrace soils, generally shallow or gravelly; dairy, poultry, and livestock farming; rainfall 18–24 inches.
6. Okanogan Valley; glacial outwash and upland glacial soils; terrace soils, shallow and gravelly, upland soils deep and productive but erodible if steep; livestock farming with orchards on irrigated land; rainfall 6–12 inches.
7. Goldendale Valley and The Dalles Bench; residual soils, erosion severe; grain, hay, and livestock; rainfall 13–20 inches.
8. Arid range lands; soils variable and shallow; topography rough; grazing land; contains areas of abandoned land; rainfall 6–8 inches.
9. Southern Idaho wheat-fallow area; loessial and alluvial outwash soils; light textured; readily eroded by wind and water; moderately productive depending on depth and rainfall; rainfall 8–18 inches.
10. Irrigated lands; light to medium-textured soils; moderately to highly productive; agriculture mostly intensive depending on quality and depth of soil and availability of water; some areas of alkali accumulations.
11. Klamath and Goose Lake Basins; mostly terrace soils; light-textured; erodible by wind and water unless protected, moderately productive depending on rainfall or irrigation; field crops, specialty crops, and pasture; rainfall 10–15 inches.
12. Willamette Valley foothills; residual soils, slopes slight to steep; farming diversified to intensive; rainfall 40–50 inches.
13. Willamette Valley bottom lands; old and recent alluvial soils, productive; wide adaptation to crops; overflow on first bottom; rainfall 35–45 inches.
14. Coastal river valleys; alluvial bottom lands and river terraces originally forested; agriculture variable, dairying and specialty crops; rainfall 30–70 inches.
15. Poorly drained valley bottom lands; alluvial soils, drainage required; grain and grasses; rainfall 38 inches.
16. Coastal cut-over foothills area; residual soils, topography rolling; productivity low to moderate; erodible when steep and not protected; pasture and hay with livestock; rainfall 16–60 inches.
17. Mountainous area; principally forest and forest-grazing use; soils shallow and stony and slopes steep; climate varies greatly with location.
18. Sand dunes, coastal and inland; wind erosion severe; productivity low.

Preface

This publication describes the use of grasses and legumes for soil conservation on farms and ranches in the Pacific Northwest. The information is based on 12 years of observational and testing work by the Soil Conservation Service in its nurseries and on farms in soil conservation districts under actual field conditions.

More than 7,000 accessions of grasses and 500 accessions of legumes have been observed and tested in the Soil Conservation Service nurseries. Of this number 5,700 were collected by the Service from the native vegetation of the Northwestern States and brought into the Service nurseries for observation as to their value for soil conservation use in any locality or wherever adaptable in useful rotations. This procedure follows an early policy of the Soil Conservation Service of carrying out observational tests of any and all native plants that show promise of fitting into American agriculture at any point, especially as they may prove of value for soil and water conservation. In addition, a number of accessions came from experiment stations in the United States and Canada.

The observational testing of such a large number of plants was facilitated by dividing them into groups that reflected a use or a common quality affecting use in soil and water conservation. The information is presented in this manner. The species in each group are divided into those of primary importance, those of secondary importance, and those that have been discarded. Many species of primary importance contain several distinct strains, climatic races, or varieties, and the differences are described.

The use of conservation seedings for green manure, hay, pasture, range, crop rotations, and silage by farmers and ranchers is recognized, and the value of the materials for these purposes is recorded. This has been possible because all of the work was done in cooperation with the agricultural experiment stations in Idaho, Oregon, and Washington and with the Bureau of Plant Industry, Soils, and Agricultural Engineering of the United States Department of Agriculture.

A map of the Pacific Northwest has been made showing agricultural zones, and the adaptation of each grass and legume to these zones is given. The Pacific Northwest is diverse in climate, topography, and soils; and agricultural enterprises vary with these conditions. The zones were made according to the different combinations of rainfall, elevation, length of season, severity of erosion, and soils that affect adaptation and use of crops and the choice of grasses and legumes for soil and water conservation.

The nurseries of the Soil Conservation Service are located at Aberdeen, Idaho; Bellingham, Wash.; and Pullman, Wash. Supplementary observation and testing has been done at Sandpoint and Tetonia, Idaho; at Moro, Pendleton, Union, and Warrenton, Oreg.; and at Goldendale, Prosser, and Lind, Wash. The authors give special credit to: The Aberdeen Branch Experiment Station, the Sandpoint Branch Experiment Station, and the Tetonia Branch Experiment Station in Idaho; the Sherman Branch Experiment Station, the Pendleton Branch Experiment Station, and the Eastern Oregon Livestock Branch Experiment Station in Oregon; and the Dryland Experiment Station, the Irrigation Experiment Station, and the Washington Agricultural Experiment Station in Washington. The authors have drawn heavily on the work conducted by W. E. Chapin, J. L. Schwendiman, and R. H. Stark, managers of the Soil Conservation Service Nurseries. They acknowledge the counsel and advice of H. A. Schoth, senior agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering. G. W. Fischer, formerly associate pathologist in the Division of Forage Crops and Diseases, made detailed studies of plant diseases in the nurseries and supplied records of his findings.

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GRASSES AND LEGUMES FOR SOIL CONSERVATION IN THE PACIFIC NORTHWEST

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Group 1. Rapid-Developing, Short-Lived Grasses

The grasses in this group have strong seedlings and reach full production in the second growing season. With a single exception, these grasses have large seeds, and all but one produce heavy seed crops. All of them are palatable, although many are coarse and become stemmy when mature. These characteristics make them useful in short crop rotations employing mixtures of sweetclover or red clover with grass. Most of them depend on natural reseeding for longevity.

GRASSES OF PRIMARY IMPORTANCE

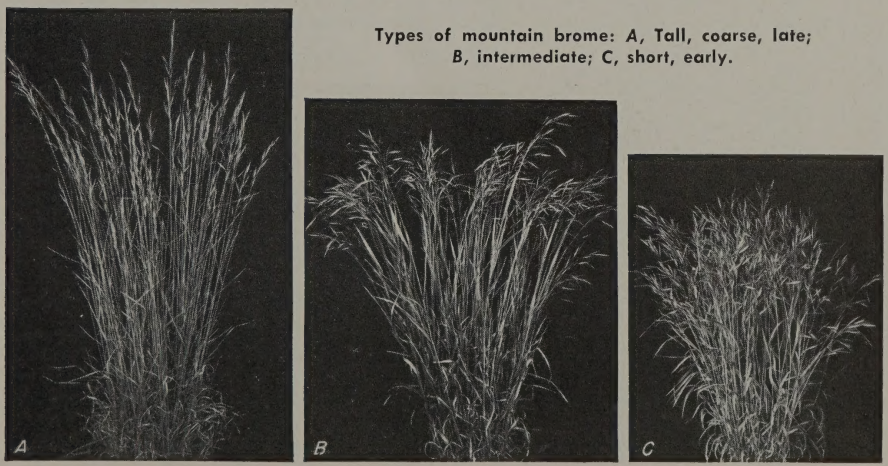
MOUNTAIN BROME (*Bromus marginatus*) is a domesticated native grass. It does best on prairie and foothill soils that receive 15 to 30 inches of rainfall, but at high elevations less rainfall is required. It is unusually well adapted for mixtures with sweetclover that are used for green manure or as dual-purpose pasture and green-manure crops. The mixture is used on land-capability classes II, III, and IV in zones 1, 2, 5, 9, and 10.[1] The grass in the mixtures makes a good ground cover to protect the soil during the winter rainfall period. The mixture should be 10 pounds of mountain brome and 5 pounds of sweetclover. The seedings are made in the spring, and the crop will contain 20 to 25 percent grass. Such a mixture was pastured at Pullman, Wash., and produced 287 pounds of beef per acre in the second year (*2*).[2]

Mountain brome has given good results when seeded alone on burned-over land in northern Idaho. The large heavy seeds and the strong seedlings made a quick ground cover to prevent erosion. The grass grows well because it is shade tolerant. It maintains itself by reseeding from heavy seed crops. An advantage in using mountain brome for this job is that the seed is relatively cheap.

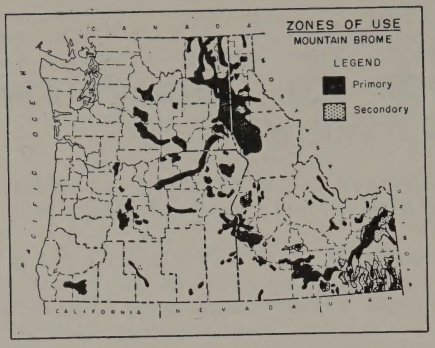
There are 4 distinct types of northern

[1] Land-capability classes referred to in this publication are described by Hockensmith and Steele (*4*).

[2] Italic numbers in parentheses refer to Literature Cited, p. 54.



Types of mountain brome: A, Tall, coarse, late; B, intermediate; C, short, early.

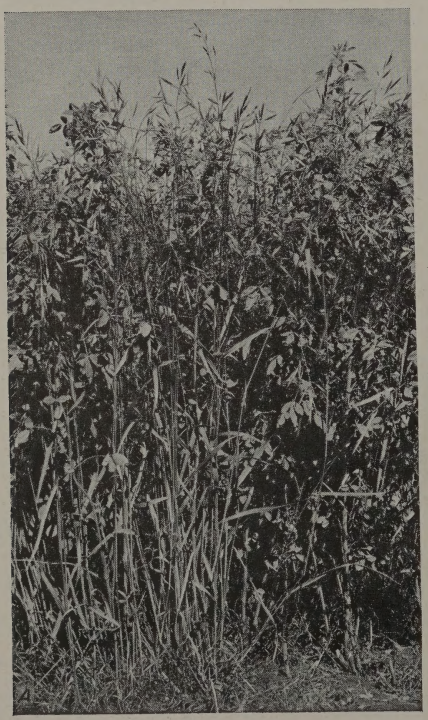


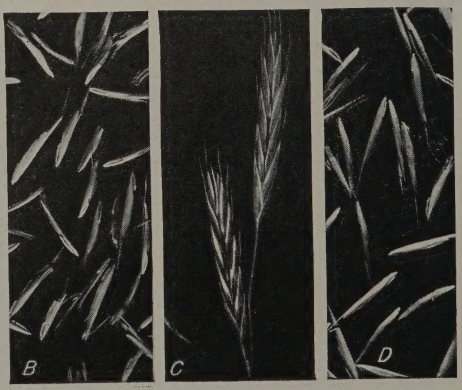
mountain brome among the 154 accessions under test. One type is short, early, and produces abundant seed. Another is tall, robust, coarse, and late. An intermediate type is the most useful for conservation seedings. These 3 types are illustrated. The fourth type is hairy but quite drought-tolerant. All of them are susceptible to several plant diseases, but head smut and mildew are most common in the field. A strain of the intermediate type has been developed and named Bromar (*6*). It is resistant to diseases, particularly head smut, and is ideally suited for growing with sweetclover. Certified seed of Bromar is on the market.

Bromar mountain brome is leafy and late. It grows and matures with Spanish and other tall sweetclovers. It is also compatible with red clover, and this mixture is planted in short rotations on shallow soils. Bromar can be planted with alfalfa but disappears from the stand during the third year. It provides ground cover and keeps out weeds and weedy grasses during the first 2 years. Because it is high in crude protein and digestible carbohydrates, the mixture makes good hay (*7*).

Sweetclover-Bromar mixtures in zone 2 are used in soil-conserving crop rotations as green manure to provide organic matter and nitrogen. The production of tops and roots varies with the season, but when the grass makes up 20 percent of the mixture, yields of 2.5 to 4.5 tons can be expected. This will be slightly less than sweetclover alone. Root production will vary from 1,500 to 2,400 pounds. This will be two times more than sweetclover alone and 70 percent will be grass roots. The use of the grass in the mixture increases root production, and this improves soil structure.

All mountain brome is strongly self-fertile (*18*). This makes it easy to maintain a strain like Bromar. Seed can be produced from solid seedings or in rows, and production is heavy for

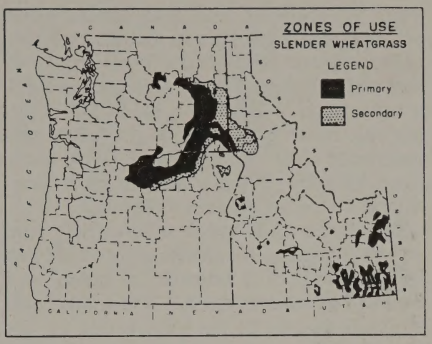




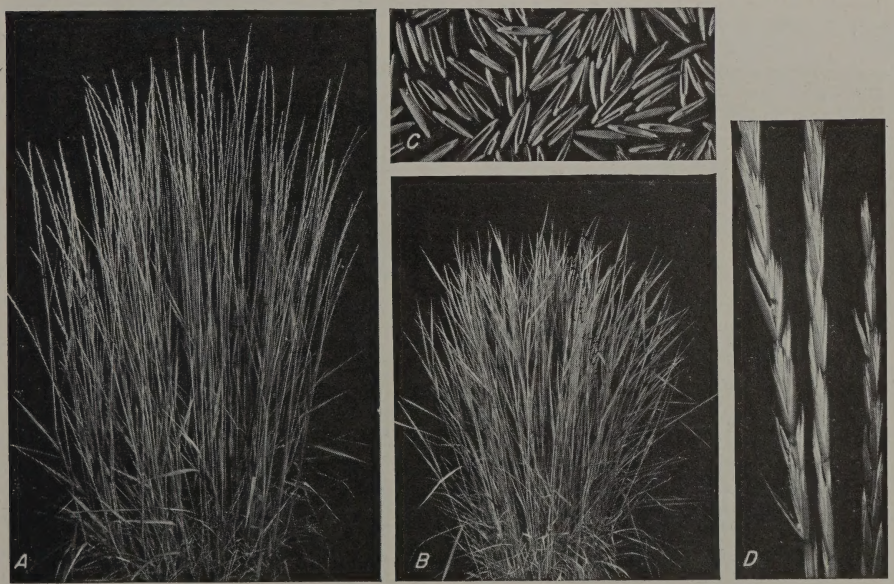
A, Sweetclover-mountain brome mixture; *B*, processed seed; *C*, florets; *D*, threshed seed (x 4/5).

the first two crops. The row plantings can be kept clean by cultivation and will produce good seed crops for more than 2 years. Average seed yields have been 500 pounds per acre on good land in semihumid areas and 600 pounds per acre under irrigation. Optimum seed production was obtained at Aberdeen, Idaho, by adding 75 pounds of nitrogen as ammonium sulfate each year. The seed shatters easily; so the crop is bound and shocked when the seed is in the dough stage. When it is cured, threshing is easy, but the seed must be processed before it is cleaned. Processing removes the awns so that the seed can be planted with farm drills (*17*). See table 1, appendix, for seed statistics.

SLENDER WHEATGRASS (*Agropyron trachycaulum*) is a domesticated native bunchgrass that is adapted to use with sweetclover where the soils are lighter and the rainfall less than that required for mountain brome. The mixture is used on land-capability classes II, III, and IV in zones 2, 3, and 9, where the rainfall is 15 to 25 inches. Slender wheatgrass can also be used with alfalfa but does not stay in such a mixture more than a few years.



Slender wheatgrass was not used on farms in the Northwest until a strain was developed that was adapted to the climate. Commercial slender wheatgrass did not begin growth until late spring and matured in the summer after the soil moisture was gone. Primar slender wheatgrass was a selection from native stands. It was chosen from 104 accessions that were divided into 6 types. These types varied in rate of spring growth, date of maturity, leafiness, height, length of life, yield, and other characteristics. Primar was one of the intermediate strains chosen because it grew and matured



Slender wheatgrass: *A*, Plants of Primar (x 1/15); *B*, plants of Mecca (x 1/15); *C*, seeds (x 4/5); *D*, heads (x 4/5).

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with sweetclover and was better than commercial varieties in other respects (*15*). Many trials have been made to compare Primar with Mecca slender wheatgrass. Primar was 10 days earlier, more resistant to diseases, and produced 500 pounds per acre more than Mecca. With sweetclover it produced twice as much as Mecca.

Mixtures of slender wheatgrass and sweetclover are seeded in alternate rows in the ratio of 8 pounds of grass to 5 pounds of sweetclover. Such mixtures contain about 15 percent grass in the top growth. They yield slightly less top growth than sweetclover alone but produce twice as much root growth. Averages for top growth have been 2.5 to 3.5 tons per acre and for root growth have been 1,500 to 2,000 pounds.

Slender wheatgrass is strongly self-fertile (*18*). It is usually sown in solid stands for seed production where the rainfall is 18 inches or more. Ten pounds of seed is used per acre. Primar has averaged 500 pounds of seed per acre for three crops and often makes 300 pounds the year it is planted. Seed production requires 40 to 60 pounds of nitrogen per acre each year. Under irrigation in 24-inch rows with 40 pounds of nitrogen each year, Primar averages 800 pounds of seed per acre for 5 years. Binding and shocking when the seed is in the dough is the best way to harvest. The crop can be combined, but the seed may shatter with strong winds. The seed is easy to thresh and clean with ordinary equipment. Seed statistics are given in table 1, appendix.

BEARDED WHEATGRASS (*Agropyron subsecundum*) is a native grass similar to slender wheatgrass in use and adaptation but is more vigorous and longer lived, although not quite as leafy. It makes twice as much growth as Primar slender wheatgrass the first season and always produces seed the year it is planted. When it is mixed with sweetclover the percentage of grass is greater, and the mixture yields more than sweetclover-slender wheatgrass mixtures.

There are 2 types of bearded wheatgrass among the 36 accessions collected from native stands. The first is tall, coarse, broad-leaved, and resistant to

Bearded wheatgrass: *A*, Heads (x 1); *B*, seeds (x 1); *C*, plant (x 1/12).



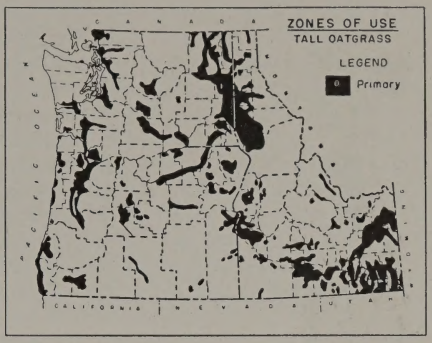


stripe rust. The second is medium tall, fine-stemmed, narrow-leaved, and susceptible to stripe rust. It is the high-elevation type and is found in the timbered foothills. The most promising strain is from the first type; it produces as much as 27 percent of the top growth in sweetclover-grass mixtures when slender wheatgrass makes up only 15 percent of the mixture.

Bearded wheatgrass is strongly self-fertile and has 2n=28 chromosomes (*18, 3*). It has the same cultural requirements as slender wheatgrass and is handled in the same way for green manure, pasture mixtures, and seed. The best strains have yielded 850 to more than 1,000 pounds of seed per acre in row plantings under irrigation.



Tall oatgrass (x 1/11).

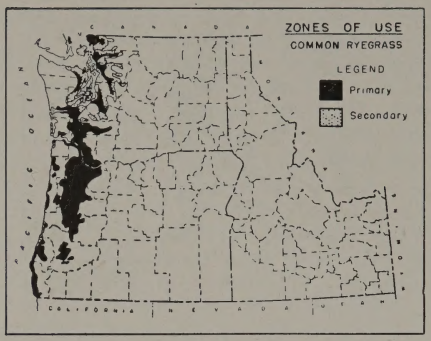


TALL OATGRASS (*Arrhenatherum elatius*) is a rapid-developing grass that has wide adaptation in semihumid areas and under irrigation. It is tolerant to shade and to a variety of soil conditions. It is used with sweetclover as a green manure in zones 1, 2, and 5 and in pasture mixtures in zones 9, 10, 13, and 14. It is also used to reseed burned-over timberlands. The young plants are vigorous and produce a good ground cover, and older plants grow fast in the fall and again in the early spring. Root production is good.

Tall oatgrass is very palatable and recovers rapidly after grazing. It is a



Tall oatgrass: *A*, Seeds threshed; *B*, seeds processed; *C*, heads (x 1).



good pasture plant. With subirrigation at Union, Oreg., it was one of the most palatable pastures and provided 325 animal-unit days of grazing per year, the highest of 18 grasses in the test (*13*). Tall oatgrass does not stay in pasture mixtures with close grazing because it has a very upright growth and is easily eaten too closely. Under proper use it is long-lived. Pasture mixtures containing tall oatgrass, orchard grass or tall fescue, and white clover were the highest in yield at Bellingham, Wash. Under close clipping the tall oatgrass went out of the stand.

Sweetclover-tall oatgrass mixtures produce as much top and root growth at Pullman, Wash., as sweetclover-mountain brome mixtures. The tall oatgrass does not produce too well on severely eroded soils, and this, along with the greater cost of seed, limits its use for green-manure mixtures.

Of the 30 accessions tested, 2 types were found: the common and an improved strain named Tualatin. Tualatin tall oatgrass is leafier and later than the common, has small corms at the base of the stalks, and does not shatter. Differences in production of tops and roots between this variety and common tall oatgrass are not significant, but the resistance to shattering is a great advantage to seed production.

Tall oatgrass is weakly self-fertile (*18*). Seed production in cultivated rows has averaged 350 pounds per acre. The crop is bound and shocked and then threshed when it is well cured. The seeds are light, fluffy, short-awned, and tend to ball up in the drills, but processing overcomes these difficulties. Processed seed must be used soon after it is treated or germination may decline (*16, 17*). The dust from threshing and processing is irritating and should be avoided. The seeds of tall oatgrass are especially attractive to mice and other rodents. For this reason the grass sometimes fails to spread by volunteering, especially when used on burned-over forest lands. See table 1, appendix, for seed statistics.

COMMON RYEGRASS is domestically grown ryegrass that is usually a mechanical or genetic mixture of Italian ryegrass and perennial ryegrass. It is a rapid-developing, short-lived perennial under the mild climate of western Oregon and western Washington, where it is extensively used.

In the Pacific Northwest common ryegrass is of greatest conservation use as a cover crop in orchards, a green-manure crop, or temporary ground cover and pasture on land-capability classes I to IV in zones 12, 13, 14, 15, and 16. It is especially well adapted for use in mixtures for permanent control of coastal dunes in zone 18. Common ryegrass produces little forage or good ground cover on low-fertility soils unless nitrogen fertilizer is used.

Common ryegrass has an especially vigorous seedling, and when it is used in pasture seedings with more slowly developing species it acts as a smother crop. It often weakens the stands so severely that they must be reseeded to maintain their erosion-control value and production.

At Bellingham, Wash., on land-capability class III, a mixture of common ryegrass and red clover produced more forage during the first year than any other mixture, as is shown below.

Type of seeding	Yields, dry matter, per acre		
	1945	1946	Total
	Pounds	*Pounds*	*Pounds*
Common ryegrass and red clover	11,200	11,105	22,305
Perennial grasses and legumes	5,400	17,807	23,207



Strains of Canada wild-rye.

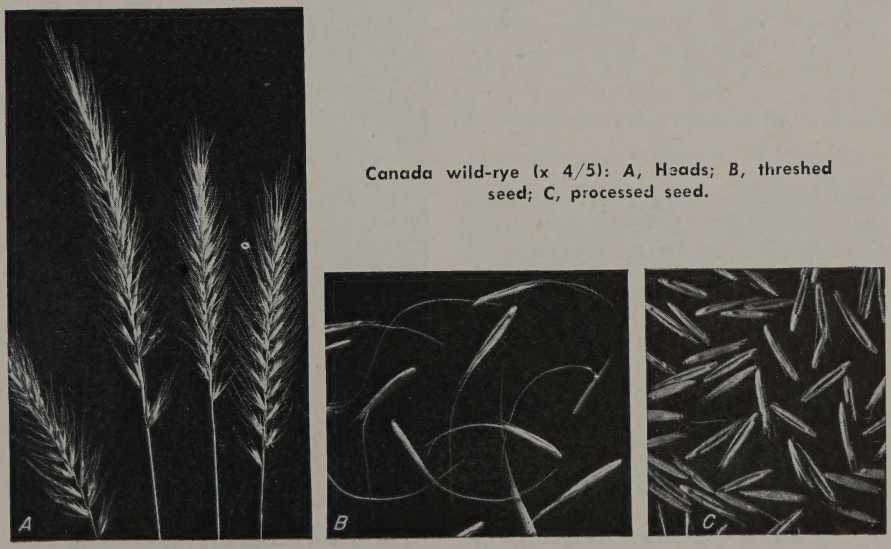
The rates of seeding were 30 pounds of ryegrass and 10 pounds of red clover. The seeding was made in late April and was fertilized and irrigated. This mixture has many uses. It makes an excellent green-manure or cover crop, a silage crop, a short-rotation clean-up crop in weed-infested areas, or a temporary pasture.

On coastal sand dunes common ryegrass is a vital part of the seed mixture used for permanent dune-control seedings. Because of its vigorous seedling, fall-seeded common ryegrass produces a protective cover against sandblast for the more slowly developing long-lived grasses and the legumes in the mixture. The low-fertility level of the dune sand, even when fertilized, does not let common ryegrass develop into a smother crop.

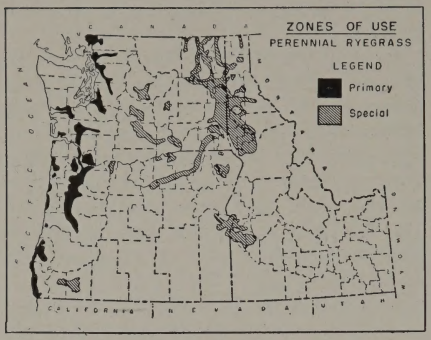
In the Pacific Northwest common ryegrass is not attacked by any serious diseases. It is not affected by the blind-seed disease that damages perennial ryegrass. Seed production in the United States is confined largely to the Northwest in zone 15, with some in zone 13. In these areas the soils are heavy and tend to be low in fertility because of poor drainage. Vegetative growth is not excessive to the detriment of a seed crop, and average yields are 600 to 700 pounds per acre. Seed is seldom produced on high-fertility soils because the plants lodge, and this reduces seed yields and makes harvesting difficult. Seed statistics are given in table 1, appendix.

Italian ryegrass (*Lolium multiflorum*) has been tested in the nurseries. Of the 10 accessions in the trials, none has been significantly different in either vegetative or seed production, nor has any of them been superior to common ryegrass.

PERENNIAL RYEGRASS (*Lolium perenne*) combines strong seedlings, rapid development, high seed yields, and good-quality forage to make it widely used for conservation seedings on land-capability classes I, II, and III in zones 13 and 14. It is a relatively short-lived perennial.



Canada wild-rye (x 4/5): A, Heads; B, threshed seed; C, processed seed.



Perennial ryegrass seedlings are not as vigorous as those of common ryegrass, but care must be taken when it is used in mixtures or it may smother the slower growing, long-lived perennials. A well-balanced mixture that can be used for pasture and soil protection in zone 14 contains perennial ryegrass 3 pounds, orchard grass 4 pounds, tall fescue 6 pounds, and white Dutch clover 2 pounds. This was 1 of the 3 highest producing mixtures among 20 under test at Bellingham, Wash. Much of the perennial ryegrass seed used in the United States is produced in zones 13 and 15. Yields average 400 to 500 pounds per acre. Blind seed disease has attacked this species, but the use of certified seed is insurance against purchase of infected stock.

Two cold-hardy strains occurred among the 53 accessions of perennial ryegrass. Both are resistant to disease and have maintained good stands for 6 years at Pullman, Wash. One of them, P–312, was selected from P. I. 107,071 and is used in zones 2, 5, and 10.

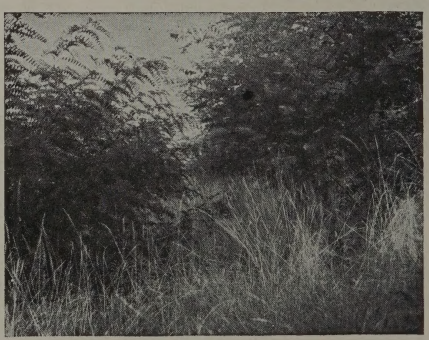
GRASSES OF SECONDARY IMPORTANCE

BULBOUS BARLEY (*Hordeum bulbosum*), P. I. 107,361, is an introduced grass. It has the largest seeds and the best seedling vigor of any grass in the group and makes a good ground cover the first season. It is tall, stemmy, and coarse and resembles the cereals in appearance. At the base of each stem is a large hard corm from which the next year's stems are produced. These corms are relished by hogs and rodents. The roots are coarse and abundant. Bulbous barley requires good fertile soils and abundant moisture and gives high yields under these conditions. It is compatible with sweetclover, but the yield of seed is low, making it too expensive to warrant its use for this purpose. Average seed yields are 200 pounds per acre. The seeds shatter badly and require processing before they can be planted with drills (*17*). Eight accessions have been tested and no differences were found.

CANADA WILD-RYE (*Elymus canadensis*) is a native grass that occurs in pure stands on wet alkaline sites. It is more tolerant of alkaline conditions than any grass in this group. It is coarse and robust and remains green at least 3 weeks later in the summer than the others. Total production from the best strains is more than other grasses in this group, both when clipped and when harvested as hay. Under subirrigated conditions at Union, Oreg., it has averaged 4.56 tons of hay per acre. Seed yields average 800 pounds. These are all desirable qualities, but seedling growth is slow in the cool weather of early spring and spring recovery of established stands is also slow. These qualities do not make it a good grass to grow with sweetclover in soil-conserving mixtures except on wet alkaline sites in short rotations in zones 8 and 10.

There are 5 types among the 60 northern accessions in the test: (1) Tall, coarse, and early; (2) tall, coarse, and late; (3) short, fine-stemmed, and early; (4) medium coarse, medium tall, and medium early; and (5) dwarf, fine, and very late. The most productive strain is from the medium type.

Canada wild-rye is strongly self-fertile. The seed does not shatter, but it has long awns that make threshing difficult. It is usually bound and shock-



Blue wild-rye cover crop in farm wood lot.

cured and threshed with a stationary machine. Much seed is recovered by rethreshing the straw. The long awn is removed by processing (*17*).

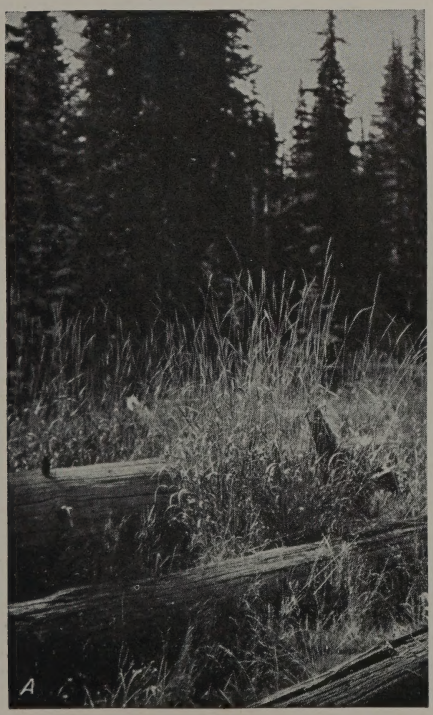
BLUE WILD-RYE (*Elymus glaucus*) is a native bunchgrass found in timbered areas from the seacoast to high elevations in the Rocky Mountains. It is tolerant of shade, produces a heavy seed crop, and is persistent in pure stands because it reseeds itself easily. On agricultural lands it has greatest usefulness as a permanent ground cover in woodlots, especially on steep slopes. In a test with several other grasses and grass-legume mixtures in a black locust woodlot at Pullman, Wash., blue wildrye made the best ground cover and offered the least competition to the trees. It develops good stands on burned-over forest lands, and processed seed is easy to handle when planting these areas. Some strains have promise as a self-seeding cover crop in orchards.

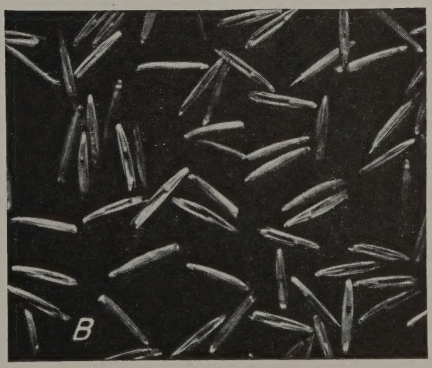
There are many strains of blue wildrye, and they are easy to keep pure because this grass is strongly self-fertile (*18*). The 263 accessions tested are divided into three types: (1) Tall, coarse, erect, leaves high on the stem, good seed production; (2) medium tall, leaves near the base of the stems, good seed production; and (3) dwarf, fine-stemmed, narrow leaves near base of the stems, poor seed production. Each type contains strains with green, purple, or mixed heads. Coastal and interior strains in each type vary in their resistance to rust; the best from the coast are resistant to brown stripe rust and the best from the interior to yellow stripe rust. The best strains for general use are from the first type, and strains in the second show promise for self-seeding cover crops.

Seed is easy to grow in solid stands, but the crop must be bound to prevent shattering. Yields of 300 to 400 pounds per acre are obtained and the seed must be processed to remove the awns (*17*).

The use of TIMOTHY in conservation seedings is limited to burned-over and cut-over land, gully seedings, and special areas where a hay crop is needed in a short rotation. Its use is restricted since tractors have replaced horses. Seed is not expensive and is easy to handle.

The 93 accessions of timothy that have been tested could be grouped into 3 general types. Common timothy (*Phleum pratense*) was divided into the tall, bunchy and the dwarf, creeping types. The dwarf, creeping type represented by S–50 is susceptible to severe infections of leaf rust and is low in production but does develop a compact sod on good soil. The tall hay type contains many named strains that





Blue wild-rye: *A*, Native habitat; *B*, processed seed.



Asiatic timothy (x 1/12).



Common timothy, tall (x 1/12).

vary principally in earliness and leafiness. Very late strains are preferred for zones 13 and 14 and very early strains in zones 1, 2, and 5. They make good mixtures with red or alsike clover. Root production is low for all types of common timothy. The third type is represented by Asiatic timothy, *P. boehmeri* (P. I. 111,701). It is a tufted, short, bunchgrass with long heads and an abundance of basal leaves that provide a good ground cover. It requires less moisture than common timothy, has been longer lived, produces high yields of seed, but is lower in total production of top growth. *P. phleoides* (P. I. 108,677) is very similar to *P. boehmeri.*

OTHER RAPID-DEVELOPING, SHORT-LIVED GRASSES were tested. *Bromus carinatus, B. polyanthus,* and *B. breviaristatus* were considered forms of *Bromus marginaus; B. maritimus* and *B. sitchensis* are similar to but weaker than *B. marginatus. Agropyron caninum, A. semicostatum, A. ciliare,* and *A. latiglume* were similar but less useful than slender wheatgrass. *Elymus ambiguus, E. antarcticus, E. interruptus, E. macounii, E. virescens, E. virginicus;* and the introduced species *E. sibiricus* and *E. dahuricus* were inferior to *E. canadensis* and *E. glaucus.* A short-awned form of *E. virginicus* came nearest equaling Canada wild-rye in performance. A cereal-type grass, *Secale montanum,* compared favorably with bulbous barley.

Group 2. Rapid-Developing, Long-Lived Grasses

The grasses in this group combine strong seedlings, long life, and dense growth near the ground to make them good plants for conservation use. They do not endure drought and grow best in the cool, wet weather of fall, spring, and early summer.

GRASSES OF PRIMARY IMPORTANCE

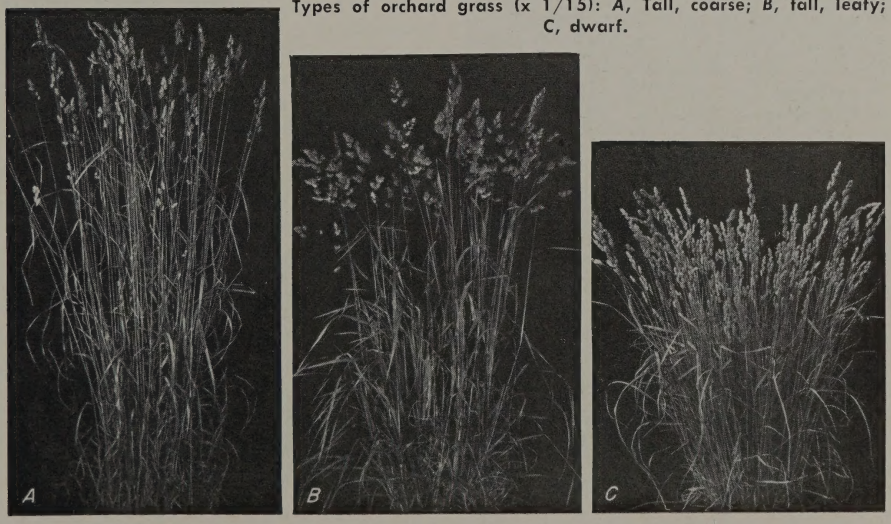
ORCHARD GRASS (*Dactylis glomerata*) has wide adaptation under semihumid conditions but is not too well adapted to low fertility or eroded soils and will not endure flooding or alkaline conditions. It is used in pasture mixtures for soil conservation on land-capability classes I to III in zones 10, 13, and 14, and on classes II to IV in zones 1, 2, and 5. It is also used with biennial legumes as dual-purpose pasture and green-manure crops in short rotations.

Orchard grass seed germinates rapidly and the seedlings are especially strong. This grass is shade tolerant; this makes it ideal for use in mixtures. A dense mat of leaves is formed near the ground the first year. These features result in good ground cover.

Orchard grass is a good root producer. The roots are medium to fine in size and make an excellent sod. The root volume develops rapidly so that as much as 2,500 pounds per acre is produced in sweetclover-orchard grass mixtures by the end of the second growing season. This is only a little less than orchard grass produces in alfalfa-grass mixtures in 6 years.

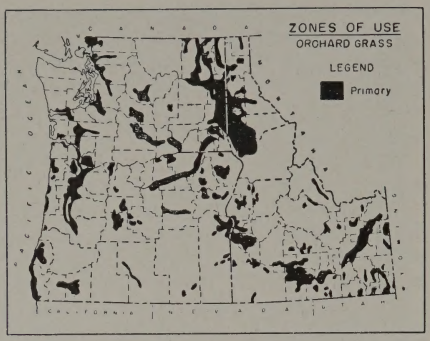
This grass is one of the most palatable grasses in pasture tests with sheep (*13*). It will go dormant with high temperatures in midsummer but remains green when irrigated. In mixtures with alfalfa under irrigation in southern Idaho the orchard grass does not make enough growth to appear in the second cutting. It is among the most palatable hay grasses (*13*). For alfalfa-grass mixtures most of the strains head too early and become fibrous. This lowers the quality of the mixed hay.

The value of orchard grass for use in conservation seedings depends on the strain that is used. Seven distinct types were found among the 107 accessions in the tests. Important differences are present in leafiness, height, cold tolerance, production, and date of maturity. All are good root producers. Five types have enough merit to continue them in the trials: (1) Tall, coarse, and late; (2) coarse and early with high seed production; (3) tall, leafy, average in maturity with low seed production; (4) coarse, medium early with good seed yields; and (5) dwarf, medium early with seed production de-



Types of orchard grass (x 1/15): *A*, Tall, coarse; *B*, tall, leafy; *C*, dwarf.

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pending on the strain. Most of the commercial seed is from the coarse, early type. The low seed production of the tall, leafy type has kept improved strains off the market. Within this type, Akaroa is the best strain in zones 13 and 14 and Brage is the best in zones 1, 2, and 5. Akaroa is not cold-hardy in zones 1, 2, and 5. The dwarf type shows promise for use in zone 10, and when pasture mixtures at Bellingham, Wash., were compared there was no significant difference between the yield of the dwarf and the tall, leafy types.

Typical conservation mixtures including orchard grass are:

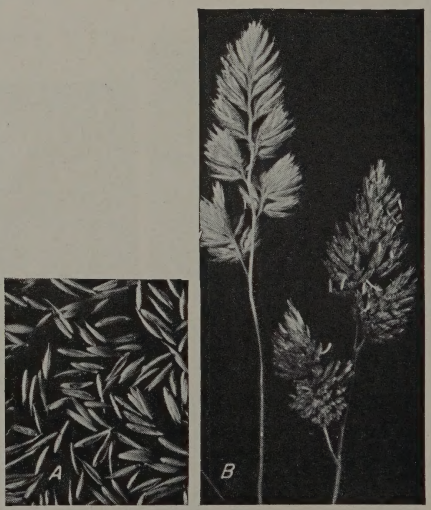
	Pounds Per acre
Pasture, zones 13 and 14:	
Perennial ryegrass	3
Akaroa orchard grass	4
Alta fescue	6
White Dutch clover	2
Alsike clover	2
Pasture and green manure, zone 2:	
Spanish sweetclover	5
Brage orchard grass	4
Pasture, zone 10:	
Manchar brome	6
Orchard grass	4
Alta fescue	6
Ladino clover	2
Hay, zone 2:	
Manchar brome	6
Brage orchard grass	4
Ladak alfalfa	5

Orchard grass is weakly self-fertile (*18*). When improved strains are grown under certification, isolation from other orchard grass plantings or volunteers is necessary. Seed is produced in cultivated rows. The seed presents no special problems for binding or for cleaning. Seed yields vary greatly by strains, ranging from an average of 72 pounds to 340 pounds per acre for the first four production years. Akaroa averaged 110 pounds and Brage 145 pounds per acre. These tests were under irrigation in southern Idaho and received 200 pounds of ammonium sulfate per acre each year. The rows were spaced 24 inches apart, and data show that more seed is produced at wider spacings. See table 1, appendix, for seed statistics.

All strains of orchard grass are susceptible to leaf spot and stem rust, especially as the plants near maturity. Severe infections are seldom found in young, growing plants in field plantings.

TALL FESCUE (*Festuca elatior* var. *arundinacea*) is ideally suited to use on irrigated, subirrigated, and wet alkaline land. Its adaptation to nonirrigated land depends on the supply of soil moisture. At elevations below 3,000 feet, 18 inches of rainfall are required, but at 4,000 to 6,000 feet less is needed. This grass remains green during the summer months but may not make much growth when temperatures are high. It survives long periods of flooding in the winter.

Tall fescue has a strong seedling and makes a dense ground cover. On good soil and with good moisture it makes a good erosion-preventing turf, especially



Orchard grass: *A*, Seed (x 1); *B*, heads (x 1).

when clipped or grazed. The ground cover and production of a pure stand of this grass on exposed clay subsoil at Pullman, Wash., where it was compared with 32 other grasses, placed it among the first 10.

Tall fescue is one of the better grasses on subirrigated alkaline soils, where it produced almost twice as much hay per acre as orchard grass and more than twice as much as meadow fescue. Only 2 grasses produced more. In the pasture trials it produced the greatest amount of green feed by weight of 18 grasses, but 2 grasses provided more days of grazing. The data from work with sheep at Union, Oreg. (*13*), are summarized in the following table.

Grass	Hay		Pasture	
	Dry matter per acre	Palatability	Green weight per acre	Animal units per acre
	Tons	*Percent*	*Tons*	*Days*
Tall fescue	3.64	65	4.00	182
Orchard grass	1.89	83		
Meadow fescue	1.67	75	3.70	229
Tall oatgrass	2.25	81	5.40	325
Canada wild-rye	4.56	59	1.50	82
Tall wheatgrass	7.33	66		

The tall fescue was high in yield but low in relative palatability. Even so, it was among the three best grasses in net tons of feed per acre under these conditions.

Tall fescue is among the five best grasses in amount of roots produced. More than 7,000 pounds of roots were in the surface-acre 8 inches in 6 years on land-capability class III at Pullman, Wash. A plot clipped each 3 weeks had more than 5,000 pounds of roots. The roots are coarse and tough and produce a good sod.

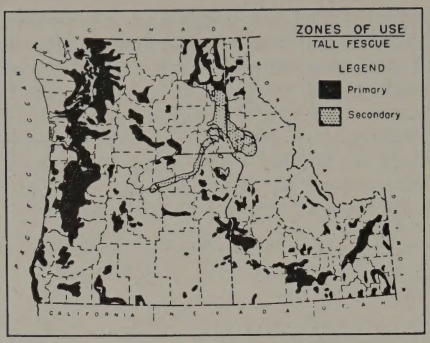
This grass is not put in conservation mixtures that will be used for hay. When planted with alfalfa, it has died out during dry summers on nonirrigated uplands at Pullman, Wash., and was crowded out of the stands in 2 years under irrigation at Aberdeen, Idaho. A mixture of tall fescue, orchard grass, perennial ryegrass, and white clover was harvested for hay at Bellingham, Wash., and no fescue was left in the stand after 3 years.

Tall fescue has been in mixture trials to find the best grass-legume mixture for soil conservation and pasture west of the Cascade Mountains. It, along with orchard grass, has given the highest production per acre and an excellent ground cover. A typical mixture including both these grasses was listed in the discussion of orchard grass. Although the fescue is rather coarse, it pastures well and persists in the mixture. It remains green throughout the year in the mild climate of this area.

More than 50 accessions of tall fescue have been tested. Four general types are recognized: (1) Very coarse, harsh, dark green; (2) medium coarse, harsh, green; (3) fine-stemmed, narrow-leaved, harsh, yellowish green; and (4) medium coarse, relatively smooth, and dark green. Named strains such as Alta, Ky–31, and California certified



Tall fescue (x 1/15).



belong to the second group. They differ only in their response to high summer temperatures.

Tall fescue is moderately self-fertile (*18*). Seed is usually produced in rows and averages 300 to 500 pounds per acre. These yields can be obtained for as much as 5 years with fertilizer and cultivation. Harvest should be with a binder to prevent shattering. No special equipment is needed to thresh and clean the seed. Detailed instructions for harvesting have been printed (*11*).

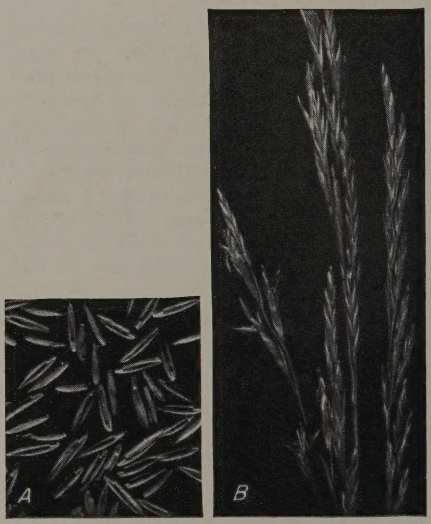
MEADOW FESCUE (*Festuca elatior*) is much like tall fescue in adaptation except that it is very short-lived in the Northwest. It is not as coarse or harsh and is more palatable. More than 70 accessions have been tested and none has sufficiently long life to recommend it. It should not be included with the other grasses in this group but is commonly regarded as similar to the important species and is widely used in other parts of the country.

SMOOTH BROME (*Bromus inermis*) is a well-known and widely used hay and pasture grass for good farm land under semihumid and irrigated conditions. It has a strong seedling and quickly establishes a good ground cover. In soil conservation work it is used in mixtures with other grasses and legumes in long rotations, in gully-control plantings, and for seeding steep slopes. Its use is on land-capability classes I to IV in zones 1, 2, 5, and 10. More recently its adaptation to parts of zone 14 has been established. It requires good soil and good drainage and will tolerate moderately alkaline conditions.

A total of 120 accessions of smooth brome, including several named strains, have been tested. They divide themselves into 2 principal types: The northern and the southern. The northern types are weakly rhizomatous, tending to be bunchy. They carry their leaves well up on the stem and have short glumes. The southern types are strongly rhizomatous, making dense sods. The leaves are near the base of



Meadow fescue (x 1/11).



Tall fescue: *A*, Seed (x 1); *B*, heads (x 1).

the stems and the glumes are long. A notable difference is the lush, early spring growth of the southern types as compared with that of the northern. This is brought out in a 5-year clipping trial at Pullman, Wash. Clipping began about May 15 each year and was repeated at 21-day intervals. The following data show that the distribution of production by the northern types is more desirable for Northwest conditions.

The northern strains vary in leafiness, seedling vigor, and production. Those that have been on the market are coarse and stemmy. One strain from Manchuria (P. I. 109,812) was recently named Manchar smooth brome. It was chosen for its leafiness, tendency to remain bunchy, exceptionally strong seedling vigor, and the tendency of the seeds to thresh free from the chaff. In comparative trials in pure stands it did not become sod-bound as quickly as southern types and gave the best production among northern strains. The seed heads are dark brown. The seeds are dark purple and much heavier than those of other smooth brome strains.

Smooth brome is used in alfalfa-grass mixtures for erosion control in long rotations. Because it is not a heavy root

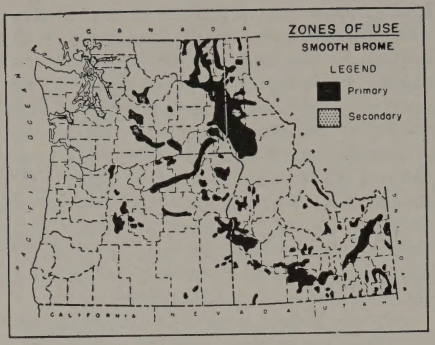
Type of brome	Yield, dry matter, per clipping			
	First	Second	Third	Fourth
	Pounds	*Pounds*	*Pounds*	*Pounds*
Northern	817	414	120	70
Southern	1,624	150	182	82



Manchar smooth brome (x 1/12).



Common smooth brome (x 1/12).



producer in the Northwest, a bunchgrass is always seeded with it. A typical mixture for zone 2 is Ladak alfalfa 5 pounds, Manchar smooth brome 6 pounds, and Sherman big bluegrass or crested wheatgrass 4 pounds. The seeds of the grass are mixed together and put in the grain box of the drill. This makes the grass easy to seed, whereas smooth brome alone does not feed through the drill uniformly or easily. The alfalfa is seeded from the legume box and in alternate drill rows with the grasses. The growth from such a mixture is usually 20 to 30 percent grass. A typical pasture mixture for irrigated lands is Manchar smooth brome 6 pounds, Alta fescue 6 pounds, orchard grass 4 pounds, and Ladino clover 2 pounds. These grasses have essentially the same season of use and are compatible in the mixture. When the pastures are clipped regularly the fescue will not become fibrous.

There is evidence that smooth brome may not be as well adapted to conservation seedings under subhumid conditions in the Columbia and Snake River Basins as some other grasses. Intermediate wheatgrass produces more top and root growth. It averaged 4,459 pounds of top growth per acre, while Manchar brome produced 2,994 pounds. Root production in the surface 8 inches was 7,424 pounds and 3,221 pounds, respectively, for the 2 grasses. No comparative pasture trials have been made, but yields from clippings were in favor of the intermediate wheatgrass. The feeding value of young brome is high, but no trials have yet been made with intermediate wheatgrass (*19*). In a 6-year trial to determine adaptation and degree of competition between several grasses at Pullman, Wash., crested wheatgrass suppressed smooth brome indicating the lack of drought tolerance of the brome. In the same trial, pubescent wheatgrass suppressed the crested wheatgrass.

Smooth brome is weakly self-fertile (*18*). Seed production is good in spaced rows, but at least 60 pounds of nitrogen is required each year to maintain production. Seed production will decline as soon as the grass becomes sod-bound. Seed yields have averaged 500 pounds for 4 years at Pullman, Wash., and 700 pounds for 3 years at Aberdeen, Idaho, under irrigation. The seed holds well and can be combined. No special cleaning problems are encountered. See table 1, appendix, for seed statistics.

GRASSES OF SECONDARY IMPORTANCE

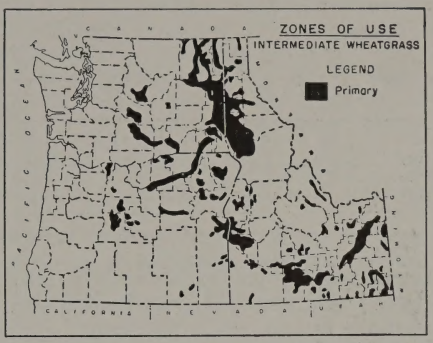
MEADOW BROME (*Bromus erectus*), P. I. 89,277, is an introduced, slightly hairy, rapid-developing, long-lived bunchgrass with high yields of roots and seed but susceptible to head smut. It has the same use and adaptation as smooth brome but is not as palatable to livestock.

BROMUS TOMENTELLUS, P. I. 111,530, is another introduced bunchgrass similar to smooth brome in use. It has a heavy growth of basal leaves that makes good ground cover. It matures seed early but the leaves remain green most of the summer. Seed production is low after the first season and this has limited its use.

OTHER RAPID-DEVELOPING, LONG-LIVED GRASSES are the native *Bromus pumpellianus, B. anomalus, B. ciliatus, B. orcuttianus, B. pacificus, B. purgans, B. suksdorfii,* and *B. vulgaris* that resemble smooth brome but are not as productive. *Festuca gigantea,* P. I. 107,917, is an awned form of tall fescue and similar to it in adaptation and use but lower in production of seed. The introduced *Festuca entremiorientalis,* and the native *F. scabrella, F. californica, F. obtusa,* and *F. occidentalis* are all inferior to tall fescue.

Group 3. Late-Maturing Grasses

These grasses are characterized by their late maturity. They grow and remain green and succulent 3 or more weeks longer than common grasses. This characteristic is of special value in an area of rainless summers. Even under irrigation they continue to grow longer than ordinary hay or pasture grasses. All of them are robust, somewhat coarse, large-seeded, and remarkably free from disease.



GRASSES OF PRIMARY IMPORTANCE

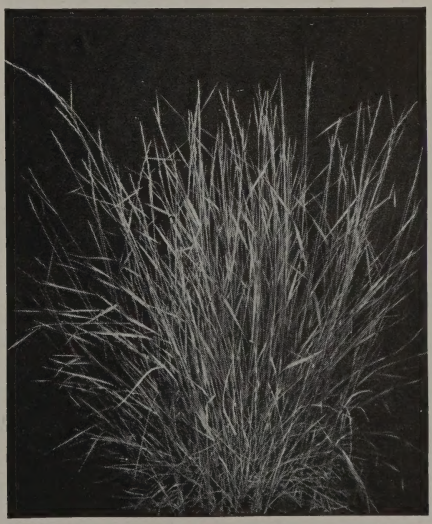
INTERMEDIATE WHEATGRASS (*Agropyron intermedium*) is adapted to use in conservation seedings on soils with good drainage and of medium to high fertility on land-capability classes II, III, and IV in zones 1, 2, 5, and 10. It is used in mixtures with alfalfa in soil-conserving crop rotations. It requires at least 15 inches of rainfall and does best at elevations of 1,000 to 3,500 feet. On prairie soils at higher elevations, such as are found near Tetonia in southeastern Idaho, it is well adapted even at 6,000 feet. On burned-over timberlands with good soil depth, high production was obtained at 3,400 feet.

Intermediate wheatgrass is a mild sod-former. It is easy to establish from spring plantings, has excellent seedling vigor, and gives a dense, leafy ground cover the first year. It makes a good mixture with alfalfa and the common bunchgrasses. It reaches the hay stage at least 2 weeks later than alfalfa, but this tends toward better quality mixed hay and the grass is not harmed by cutting when the alfalfa is ready. It begins growth in early spring and reaches pasture readiness (4 to 6 inches) about the same time as alfalfa or crested wheatgrass. It makes good growth in the early fall so that ground cover is maintained during the winter.

Intermediate wheatgrass is compared with smooth brome because these two grasses have about the same adaptation. The wheatgrass has produced more ground cover and substantially more hay or pasture than smooth



Intermediate wheatgrass, tall type (x 1/12).

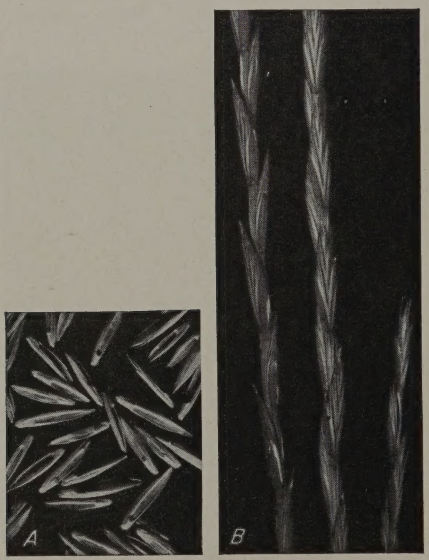


Intermediate wheatgrass, dwarf type (x 1/12).

Year	Number of clippings	Yield, dry matter, per acre when clipped		Yield, dry matter, per acre as hay	
		Wheatgrass	Brome	Wheatgrass	Brome
		Pounds	*Pounds*	*Pounds*	*Pounds*
1942	5	2,797	2,171	5,480	4,600
1943	4	2,347	1,831	4,980	3,610
1944	3	2,360	1,145	3,008	1,388
1945	3	2,445	1,110	4,370	2,375

brome whether planted alone or in mixtures. The seasonal growth of intermediate wheatgrass is distributed further into the summer months and production and stands are maintained better than with smooth brome. The table shown above, giving results obtained at Pullman, Wash., brings out these points.

Intermediate wheatgrass is high in root production. At the end of four growing seasons at Pullman it produced 7,424 pounds of root material in the surface-acre 8 inches of soil as compared to 3,221 pounds for smooth brome. The fibrous roots of grass improve soil structure, making it more absorptive for rain and thus decreasing erosion. Organic matter is usually below normal on eroded and depleted soil, and this grass returns a large amount of raw material.



Intermediate wheatgrass: *A*, Seeds (x 1); *B*, heads (x 1).

When intermediate wheatgrass is sown in grass-legume mixtures the rate of seeding is 8 pounds per acre. A typical conservation mixture for zone 2 is intermediate wheatgrass 8 pounds, Sherman big bluegrass 4 pounds, alfalfa 5 pounds. In such a mixture about 30 percent of the total production is grass.

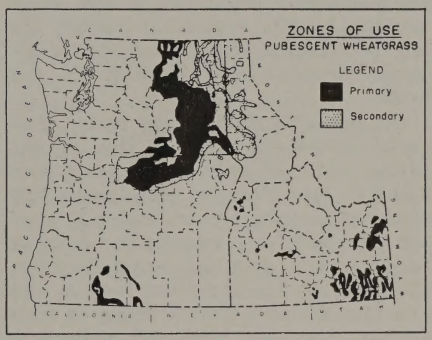
This grass is a good seed producer and averages 225 pounds for three production years. It is weakly self-fertile (*18*). It is seeded at 5 pounds per acre in rows at least 30 inches apart, cultivated, and fertilized with 40 to 60 pounds of nitrogen each production year. The stems are strong and the plants are resistant to lodging. Binding and shock curing are preferred harvesting methods. The seeds thresh easily and are heavy and beardless. They are easily cleaned and no special processing operations are necessary.

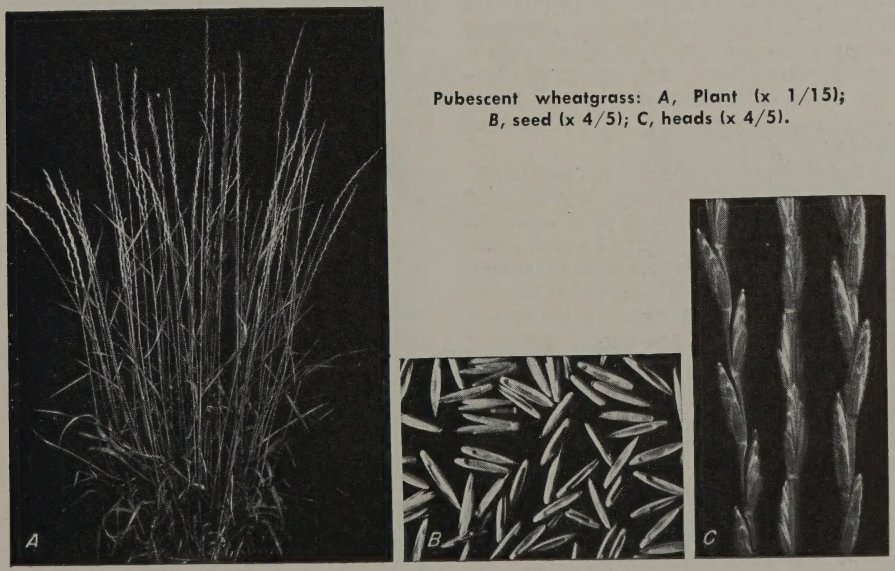
From the 10 accessions of intermediate wheatgrass that have been tested—all of them from foreign plant introductions—2 major types have been selected. One is a uniformly leafy, fine-stemmed, dwarf type that is very late maturing when moisture is adequate. The chromosome number of this type is 2n=43 (*3*). It was selected from P. I. 109,219 obtained at Bolu, Turkey. The other is tall, coarse-stemmed, broad-leaved, and of medium-late maturity. The tall type contains several different forms and it has 2n=42 chromosomes (*3*). It is from P. I. 98,568 obtained at Maikop, Caucasus, U. S. S. R. Both types seem to require the same conditions for growth. The trend of differences of these types as compared with smooth brome holds for all locations where tests have been made. The following average results from 3 years of data at the irrigated nursery at Aberdeen, Idaho, are typical.

Grass	Average date			Height	Yield per acre	
	Head	Bloom	Mature		Hay	Seed
				Inches	*Pounds*	*Pounds*
Intermediate wheatgrass, tall	June 28	July 9	Aug. 8	42	3,393	200
Intermediate wheatgrass, dwarf	June 28	July 12	Sept. 10	28	2,690	225
Smooth brome, Manchar	June 6	June 24	July 15	30	2,754	500

PUBESCENT WHEATGRASS (*Agropyron trichophorum*) is also a mild sod former. It is similar to intermediate wheatgrass in growth habits, seasonal development, cultural requirements, compatability in mixtures with other grasses and alfalfa, conservation value, and breeding habits. It differs from intermediate wheatgrass in being better adapted to lower fertility soil, alkaline soils, low-rainfall areas, and high elevations. Pubescent wheatgrass is the most palatable grass in the group and has shown greater possibilities for use as pasture than as hay. Adaptation is to soils in land-capability class VI in zones 1, 2, 5, and 7 and to class IV in zones 3, 4, 6, 9, and 11. Its use in zones 8 and 17 has not been fully determined. Some trials on burned-over timberlands in northern Idaho show it is well suited to pasture on such areas.

When the use of late-maturing, sod-forming grasses is required for conservation seedings, the choice is between pubescent wheatgrass and intermediate wheatgrass. The performance of both is compared with that of smooth brome. When the rainfall is limiting as in parts of zone 3 and in zone 4, pubescent wheatgrass has produced 50 percent more than brome. At Union, Oreg., on subirrigated land that is alkaline, this grass produced an average of 177 ani-





Pubescent wheatgrass: *A*, Plant (x 1/15); *B*, seed (x 4/5); C, heads (x 4/5).

Grass	Yield, dry matter, per acre per clipping				
	First	Second	Third	Fourth	Fifth
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Intermediate wheatgrass	1,101	718	505	222	233
Pubescent wheatgrass	1,026	678	262	253	139
Smooth brome	987	629	250	170	135

mal-unit-days of grazing per acre as compared to 105 animal-unit-days by smooth brome (*13*). Intermediate wheatgrass was not in this test because it was not adapted to alkaline conditions. The 3 grasses were compared on good soil at Pullman, Wash., under 20 inches of rainfall. They were clipped once every 3 weeks. Typical results (tabulated above) show that both wheatgrasses produced more than smooth brome, especially during the late part of the season, but at this location intermediate wheatgrass was better.

On high-capability land under irrigation at Aberdeen, Idaho, the average production per acre for 5 years was 2.16 tons for pubescent wheatgrass, 1.38 tons for smooth brome, and 1.70 tons for intermediate wheatgrass. Similar results were obtained from Tetonia, Idaho, where the elevation is 6,000 feet and the silt loam prairie soil is of high quality. In this trial the pubescent wheatgrass was highest in production in solid stands, and the intermediate wheatgrass was the best when grown in cultivated rows. This shows the better drought resistance and the lower fertility requirement of pubescent wheatgrass.

Pubescent wheatgrass is easy to establish, the seedling vigor is good, and ground cover is good the first year. In other growth characteristics it is similar to intermediate wheatgrass, except that the foliage is somewhat hairy. When seeded in mixtures, 8 pounds of seed are required per acre. Where it can be grown with a legume it is planted in the spring. It is planted in the fall or early spring under low rainfall conditions. It is ready to graze when the foliage is 4 to 6 inches tall. Good production is maintained when utilization does not exceed an average of 70 percent. Fall and spring recovery are early and good to excellent.

This species is weakly self-fertile (*18*). When grown for seed production, this grass is seeded in 36-inch rows and cultivated. Each production year 40 to 60 pounds of nitrogen is added. Seed must be grown at medium elevations where an average of 200 pounds can be expected for as long as 5 or more years. Under irrigation one planting gave the following production over 5 years: 378 pounds, 335 pounds, 211 pounds, 185 pounds, and 185 pounds. At 6,000 feet elevation this grass does not produce profitable seed yields. The seed does not shatter but it is hard to thresh. Extra concaves are required and the grass must be well cured. For these reasons, binding and shock-curing are advantageous.

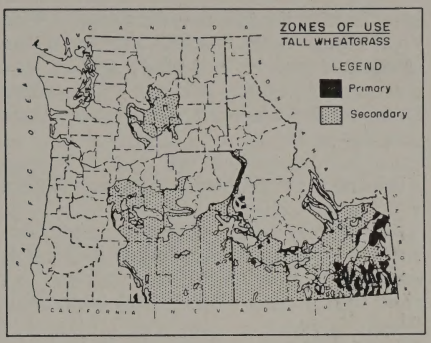
Eight accessions, all of them foreign plant introductions, have been tested and no significant differences have been noted. Accession P–41, selected from P. I. 107,330, is the one for which data are reported. It was obtained at Tashkent, Turkestan, U. S. S. R., and has 2n=42 chromosomes (*3*).

TALL WHEATGRASS (*Agropyron elongatum*) is a coarse, tall, vigorous, stemmy bunchgrass. Even so, it is more palatable than its appearance indicates, and it is one of the highest yielding grasses yet tested. It is used in pure stands for soil and moisture conservation because of its special adaptations and its late summer growth. It has special uses for land-capability classes IV and VI. It has given very high yields on subirrigated alkaline soils in zones 8 and 9. On semiarid prairie soils in zone 9 that once grew wheat but were abandoned because of wind erosion, it provides summer pasture to supplement native ranges and common grasses.

Tall wheatgrass has been late in blooming, heading, and maturing at all locations where tested; in fact, it is one of the latest grasses in the trials. Under irrigation and subirrigation it can

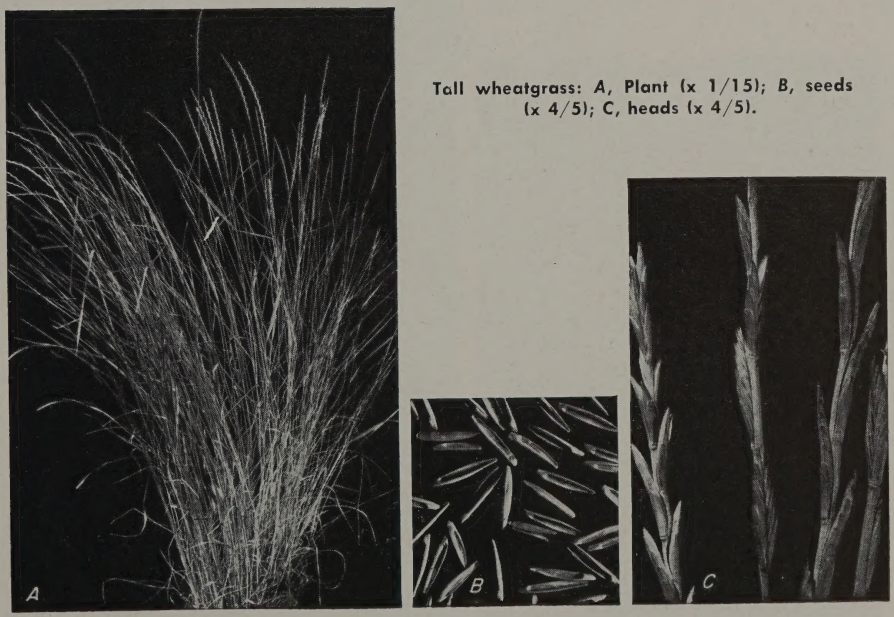
be compared with tall fescue. Under these conditions it produces more than 7 tons per acre, or twice as much as tall fescue, and it is 30 days later (*13*). Tall wheatgrass produces as much feed for hay or pasture as does crested wheatgrass under semiarid conditions at high altitudes (4,500 to 6,000 feet), and it can furnish green feed for at least 30 days after the crested wheatgrass is mature (*20*). On lands of high capability in semihumid areas or in semiarid areas at low elevation the other grasses in this group give better results.

The seed of tall wheatgrass germinates readily, but the plants develop more slowly than others in this group, especially under semiarid conditions. Stands are established from spring seedings on subirrigated soils and from fall seedings on summer fallow in the semiarid areas. About 8 pounds of seed per acre is required when drilling is in 12-inch rows on semiarid land, and 15 pounds per acre is required to plant in 6-inch rows on subirrigated lands. This grass is slow to develop to full production on semiarid land and should not be grazed until the fourth season, but when it is subirrigated it is ready to use the second season. It is grown alone rather than in mixtures.



Tall wheatgrass is moderately self-fertile (*18*). Seed production by tall wheatgrass is excellent at medium altitudes when the growing season is long. Under these conditions it averages more than 300 pounds per acre when grown in 30-inch rows and fertilized with 40 to 60 pounds of nitrogen per acre. The plants do not lodge. Harvest is by binding when the seed is in the soft-dough stage. The seed threshes and cleans with ordinary equipment.

The 13 accessions of tall wheatgrass that have been tested fall into 2 types: One is dark green and the other is blue green. No significant differences have been noted except that the dark-green



Tall wheatgrass: *A*, Plant (x 1/15); *B*, seeds (x 4/5); *C*, heads (x 4/5).

type is slightly later and coarser. The blue-green type, P–2326, has been increased from P. I. 98,256, which was introduced from Maikop, Caucasus, U. S. S. R., where it occurs on saline meadows.

GRASSES OF SECONDARY IMPORTANCE

GIANT WILD-RYE (*Elymus condensatus*) is a native grass similar in growth and adaptation to tall wheatgrass, except that it has short, thick rhizomes. Seedling vigor is low, and at least 4 years is required for establishment. There are two types: (1) Tall, coarse, and broadleaved, with either bluish-green or dark-green color; and (2) dwarf, fine-stemmed, and narrow-leaved, with either bluish-green or dark-green color.

OTHER LATE-MATURING GRASSES are the introduced *Agropyron amurense* and *A. popovii* that are similar but inferior to intermediate wheatgrass; *A. junceum* that is like pubescent wheatgrass but not as drought-tolerant; and *A. pseudorepens, A. pungens,* and *A. ramosum* that are like the native quackgrass in habit and late maturity. Quackgrass is variable and contains many good strains from which some that are not weedy might be selected to advantage. Such grasses as tall fescue and Russian wild-rye remain green into the summer but do not make much growth.

Group 4. Drought-Tolerant, Long-Lived Bunchgrasses

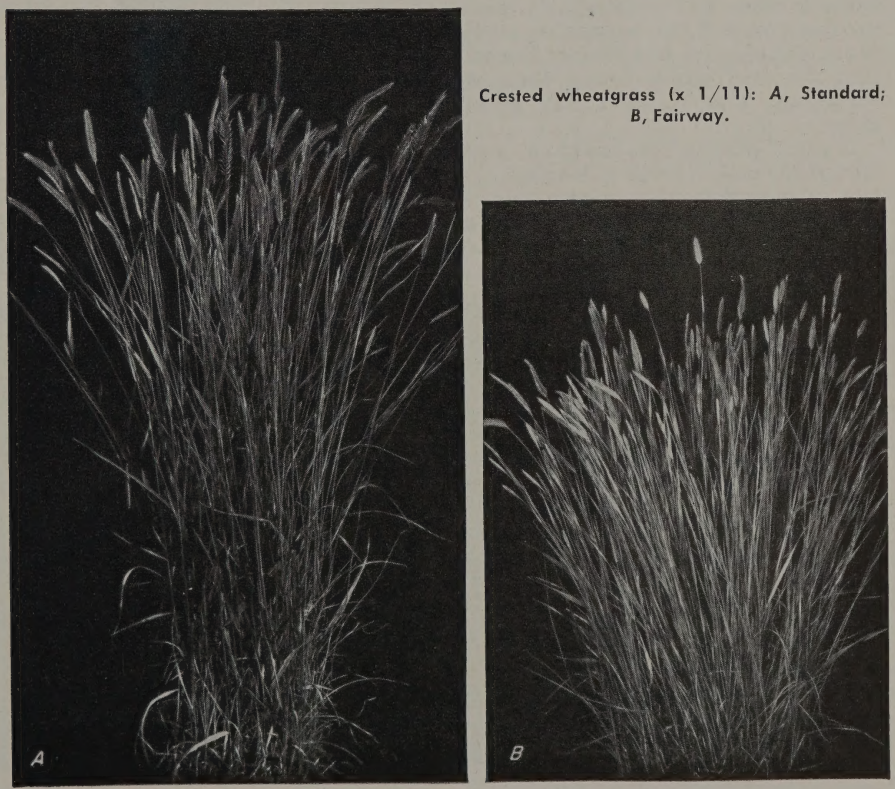
These grasses are drought-resistant. They are used in areas where wind erosion occurs and for reseeding range land. New seedings develop slowly, but established stands survive long periods of drought and give good protection in areas of low rainfall and on lands of low capability.

GRASSES OF PRIMARY IMPORTANCE

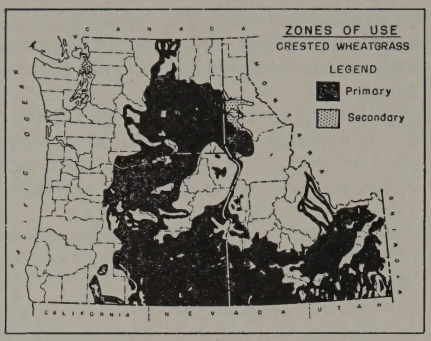
STANDARD CRESTED WHEATGRASS (*Agropyron cristatum*) is used on land-capability classes III and IV in zones 2, 3, 4, 6, 7, 8, 9, and 11. It is widely used on light-textured prairie soils where the rainfall is 9 to 15 inches. Here it is planted alone to protect soil from blowing or washing and in rotation with wheat to improve soil structure. Abandoned farm land and overgrazed ranges are planted to this grass for pasture. It is sometimes used in legume-grass mixtures on eroded cropland where the rainfall is more than 15 inches. Burned-over and overgrazed land in zones 1 and 17 can be seeded to crested wheatgrass.

It is easy to get good stands of crested wheatgrass. Germination of the seed is high. As the young seedlings develop slowly, they must be protected against grazing until they are fully established. Under semiarid conditions this requires at least 2 years (*20*). Details for making seedings have been published (*10, 21, 23*).

Established stands of crested wheatgrass remain productive for 10 to 15 years when they are managed right. Under semiarid conditions they produce about 1,000 pounds of hay or provide 1 animal-unit-month of grazing per acre (*20*). The feed value is good. The grass is grazed in the spring and in early fall. It is ready to graze when 4 to 5 inches tall and should not be utilized more than an average of 70 percent. It is palatable to livestock as long as it is green.



Crested wheatgrass (x 1/11): *A*, Standard; *B*, Fairway.



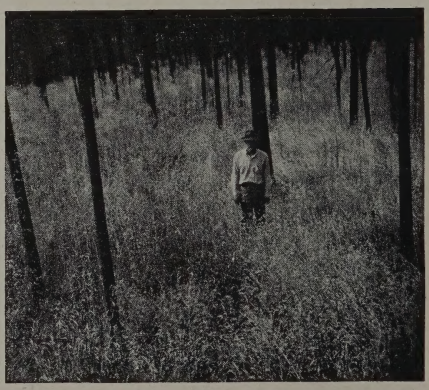
Alfalfa-grass mixtures containing crested wheatgrass protect the soil against erosion on sloping farm land under subhumid conditions. A standard mixture is crested wheatgrass 4 pounds, Manchar smooth brome 6 pounds, and Ladak alfalfa 5 pounds. Such mixtures produce about 2 tons of hay and provide 4.0 animal-unit-months of grazing per acre (2). An alfalfa-crested wheatgrass mixture produced 5,227 pounds of roots per acre when 6 years old, while alfalfa alone produced only 2,352 pounds of roots. When the mixture was plowed, the soil structure was much better than on wheatland where alfalfa was grown alone.

Crested wheatgrass produces good seed yields and the seed is easy to harvest. On good fertile soil with moderate rainfall, seed yields average 275 pounds per acre. The seed crop is usually grown in rows that are 36 inches apart and cultivated. An annual application of fertilizer that will add 40 pounds of nitrogen helps to maintain seed production. The seed can be harvested with a combine when the wind blast is reduced or nearly shut off. A careful combine operator in a clean stand can bring in seed with 80 percent purity, but it is usually nearer 50 percent pure. Cleaning is a simple matter with an ordinary fanning mill. A hammer mill can be used to break up the so-called "doubles." See table 1, appendix, for seed statistics.

A total of 224 accessions of crested wheatgrass have been tested. Many of them were new introductions and 3 types are recognized: Standard, Fairway, and a sod-forming type. Standard crested wheatgrass is weakly self-fertile and the plants vary, but even so the material on the market is more uniform and generally more vigorous than the original introduction from Siberia in 1906. Standard crested wheatgrass has a chromosome number of 2n=28 (3). The Fairway variety is distinct in being shorter, finer stemmed, and sparsely hairy and in having broader and shorter heads. It has a chromosome number of 2n=14. Its adaptation for use in conservation seedings and its yield and forage quality in the Northwest have been equal to Standard crested wheatgrass in every way (*5, 7, 13*). It differs from Standard in reseeding itself much better



Crested wheatgrass (x 4/5): *A*, Standard; *B*, Fairway.



Crested wheatgrass on burned-over land.

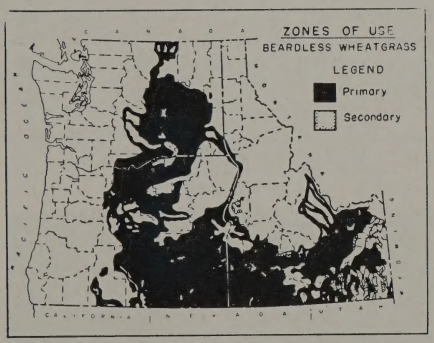
Grass and rainfall	Yield, dry matter, per acre			
	1941	1942	1943	1944
	Pounds	*Pounds*	*Pounds*	*Pounds*
Whitmar beardless wheatgrass	1,577	2,346	1,889	1,062
Standard crested wheatgrass	3,124	2,450	1,865	724
	Inches	*Inches*	*Inches*	*Inches*
Rainfall departure from average (10.4 inches)	+7.60	+2.25	−0.62	−1.44

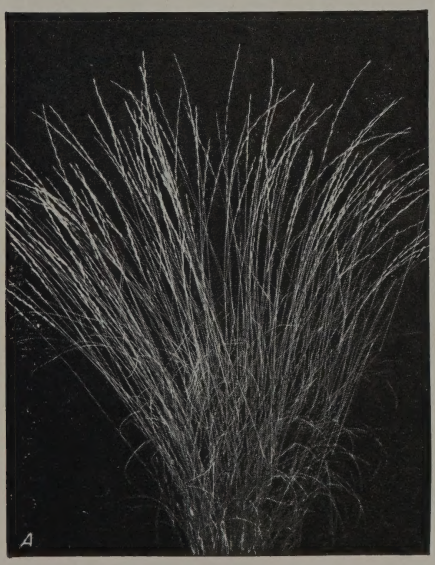
under semiarid conditions. The sod-forming type, P. I. 109,218, has a weak seedling and is very slow in its development.

SIBERIAN WHEATGRASS (*Agropyron sibiricum*), P. I. 108,434, is a recent introduction closely related to Standard crested wheatgrass and similar in appearance except that the seed heads are narrower and the awns are very short. Under semiarid conditions Siberian wheatgrass has produced more forage than Standard crested wheatgrass. At high elevations in zone 9 this grass remains green 2 weeks longer than Standard. Seed supplies are not yet available commercially.

WHITMAR BEARDLESS WHEATGRASS (*Agropyron inerme*) has been domesticated from the Palouse bunchgrass prairie. It has the same uses as crested wheatgrass on farm and range lands. This grass is more drought-resistant and has a different season of use than crested wheatgrass; so it serves to supplement plantings of crested wheatgrass in zones 3, 4, 7, 8, 9, and 11 on land-capability classes III, IV, and VI.

Whitmar wheatgrass has consistently produced more forage than crested wheatgrass in low rainfall years and under other adverse conditions. The above table shows results obtained in zone 3.









Whitmar wheatgrass: A, Plant (x 1/15); B, heads (x 4/5); C, seeds (x 4/5).



Alfalfa-Whitmar, alternate-row mixture.

Measurement of root production in zone 2 shows that Whitmar wheatgrass produces 6,100 pounds of roots per acre. This is slightly more than crested wheatgrass provides, and the roots are finer and produce a tougher sod. The difference in root production may be responsible for the greater drought resistance of Whitmar.

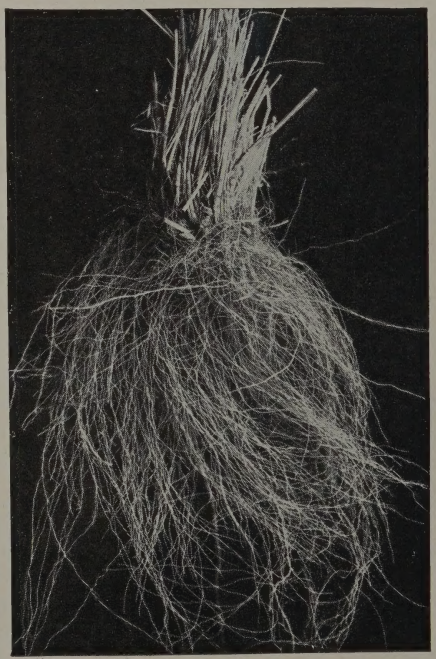
Whitmar wheatgrass is ready to graze in the spring about 3 weeks later than crested wheatgrass and remains green and palatable 3 weeks later in midsummer. It should not be grazed until it is 7 inches tall. Because of this difference in season of use, Whitmar wheatgrass and crested wheatgrass are seeded in separate fields and pastured separately to extend the grazing season (*20*). The palatability of the two grasses was equal in feeding trials with sheep (*13*).

In areas with moderate rainfall and light-textured soils (zone 3), Whitmar wheatgrass can be grown with alfalfa for hay. The grass should be seeded in alternate rows with the legume. Alternate row seedings of this grass and western wheatgrass are successful under semiarid conditions (*20*).

Good stands of Whitmar wheatgrass are obtained from early spring seedings on summer fallow. Fall seedings on fallow are usually successful but occasionally fail. Fall seedings on other seedbeds have not been successful (*20*). The grass requires 3 years to reach full production under semiarid conditions and should not be grazed during this time. When seeded alone in 12-inch rows, 8 pounds of seed is required per acre. The seed should be treated with 6 ounces of New Improved Ceresan per 100 pounds of seed shortly before planting to prevent seedling diseases that sometimes reduce the stand.

Seed is produced best from row plantings with 36-inch spacing. Yields average 300 pounds per acre for 3 crops under irrigation or semihumid conditions. The seed may be combined, but better yields and quality result from binding and threshing. It is easy to clean and does not require processing.

Whitmar wheatgrass was selected from more than 500 accessions that were collected from the native prairies. This material was divided into 6 types, and the strain named Whitmar was the best in the intermediate group. It is intermediate in height, size of stem, and size of seed but superior in yield of tops and roots and in adaptation to a wide variety of climatic and soil conditions. It is susceptible to leaf rusts in the nursery but is not attacked to any important degree in field plantings. The

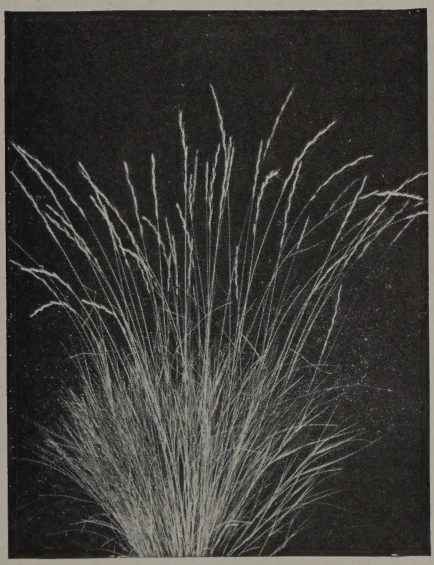


Whitmar wheatgrass, roots of one plant.

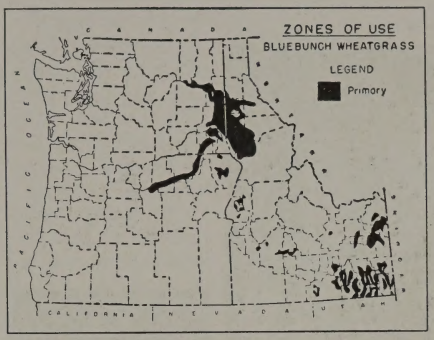
chromosome number is 2n=14 and it is weakly self-fertile (*3, 18*).

BLUEBUNCH WHEATGRASS (*Agropyron spicatum*) differs from Whitmar beardless wheatgrass in that it is better adapted to semihumid conditions, to elevations above 4,000 feet, and to use on cut-over and burned-over forest lands. It is used alone and in legume-grass mixtures on land of land-capability classes III, IV, and VI in zones 1, 2, and 9.

Bluebunch wheatgrass can be used in alfalfa-grass mixtures for erosion control and water conservation, and on forest-derived soils it is sometimes better than other grasses. It is planted alone at high elevations to reseed abandoned farm lands or overgrazed ranges. The two accessions that are used are not yet named but both are tall, vigorous, and leafy. They have large seeds with long awns and spread by short rhizomes. They were developed from collections made in the prairie-timber transition zones. Both are tetraploids with a chromosome count of 2n=28 (*3*). Bluebunch wheatgrass has the same season of use for grazing as Whitmar wheatgrass. It should not be utilized more than 60 to 70 percent or grazed before it is 7 inches tall, or it will not maintain a stand (*22*). It is planted



Bluebunch wheatgrass (x 1/15).



the same as Whitmar wheatgrass. Seed production is the same, except that the threshed seed must be processed to remove the awns before it is cleaned (*17*). The seed should be treated before planting. Stripe rust and stem rust are important diseases but seldom injure field stands.

GRASSES OF SECONDARY IMPORTANCE

RUSSIAN WILD-RYE (*Elymus junceus*) is unique among long-lived grasses adapted to semiarid conditions. The densely tufted bunches with a mass of basal leaves provide good ground cover, and a high production of fibrous roots improves soil structure so that runoff is reduced and erosion prevented. It begins growth in spring somewhat later than crested wheatgrass and matures its seeds 3 weeks earlier, but the leaves remain green throughout the summer and fall recovery and growth are better than for crested wheatgrass. The foliage is killed by heavy frost. Palatability to livestock is high in late summer and early fall and digestibility is especially good (*7*). Total production from a 1940 planting in zone 3 is low as is shown in the data on following page.

Russian wild-rye should be used in pure stands as a pasture grass in long rotations to supplement other grasses. Its best season of use is late summer and early fall. Its use is restricted because seed yields are very erratic, ranging from more than 400 pounds in 1 year to less than 20 pounds in another, even under irrigation. The seedlings are weak and the plants develop slowly, but, when once established, they are vigorous and persistent and withstand heavy utilization. The use of this grass



Russian wild-rye: *A*, Heads (x 1); *B*, seeds (x 1).



Russian wild-rye (x 1/11).

Grass	Yield, dry matter, per acre				
	1941	1942	1943	1944	1945
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Russian wild-rye	49	2,552	1,588	880	943
Crested wheatgrass	3,363	2,292	1,740	729	1,157
Big bluegrass	1,400	3,670	2,493	1,565	1,205

will be on land of land-capability classes III and IV in zones 7, 8, and 9.

Twenty accessions have been tested and there are no significant differences among them. The one being used in the Northwest is P. I. 75,737. The grass is weakly self-fertile (*18*). The chromosome number is 2n=14 (*3*). The seeds mature early and shatter readily; so they are harvested with a binder. The short awns are broken off in the thresher; so no special cleaning is necessary. Stands are established from fall seedings, 6 pounds of seed per acre being used. Statistics for seed are given in table 1, appendix.

OTHER DROUGHT-TOLERANT, LONG-LIVED BUNCHGRASSES are inferior to those listed. *Agropyron desertorum* resembles Siberian wheatgrass but is hairy. *A. saundersii* and *A. saxicola* are rare native grasses like bearded wheatgrass but are sterile, and the introduced *A. divaricatum* is hairy. *Elymus salina* grows on dry rocky slopes and is very small.

Group 5. Drought-Tolerant, Long-Lived Sodgrasses

Three sod-forming grasses have been domesticated from the native grasslands of the Pacific Northwest. They are adapted to conservation seedings under semiarid conditions, and one shows tolerance to alkaline soils.

GRASSES OF PRIMARY IMPORTANCE

WESTERN WHEATGRASS (*Agropyron smithii*) is found in the native prairie of the upper Snake River Basin and in isolated places in the Columbia River Basin. Although it is a Great Plains grass, the local collections make a good sod, a satisfactory ground cover, and good hay and pasture on light-textured soils under semiarid conditions. This makes it valuable for wind-erosion control.

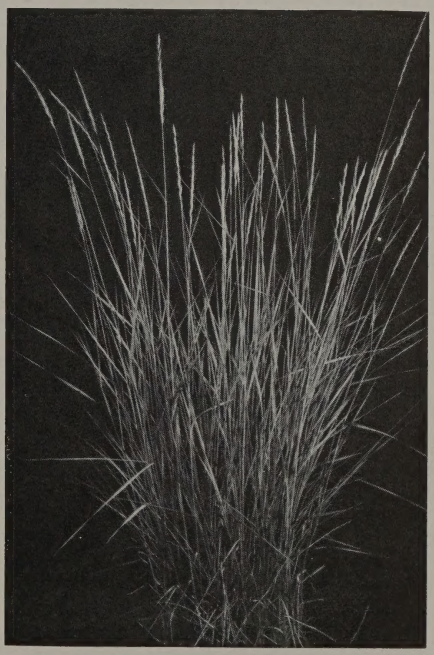
Western wheatgrass germinates slowly, and 2 to 3 years are required before it reaches full production. Spring recovery is at least 3 weeks later than other grasses in this group. It has the same season of use as Whitmar wheatgrass (*20*). Plantings of these two grasses are made in alternate rows under semiarid conditions in zone 9, but the sodgrass spreads to make a good ground cover only when the bunchgrass stand is uneven. When western wheatgrass is planted alone on these sites it provides as much ground cover and feed as crested wheatgrass or the native bunchgrasses. With 9 inches of rainfall the basal density averages 2 percent and the grazing capacity 1.0 animal-unit-month per acre (*20*). Western wheatgrass will grow through thick layers of silt in waterways and along streams that flood out of their banks. It thrives under subirrigated conditions in zones 4, 6, 8, and 9 even if the soil is slightly saline.

The rhizomes of western wheatgrass are deep and the top growth is uniform rather than bunchy. It withstands moderate usage from vehicles. These qualities have made it useful for surface protection and erosion control on airports under semiarid conditions. Even when the runways and taxying strips are dragged, this grass recovers to maintain its stand and cover.

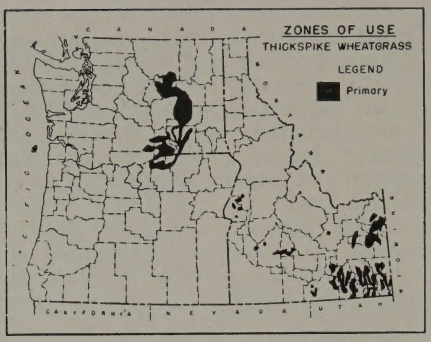
Western wheatgrass is free from plant diseases in field plantings, but ergot may occasionally occur. The hay is of good quality and cures well. This grass has a high dry-matter content, averaging 51.0 percent, while smooth brome averaged 41.2 percent and crested wheatgrass 44.3 percent in a 4-year trial.

Little difference in type occurred among the 73 accessions that have been tested. All have a chromosome number of 2n=56 except one weak accession that has 2n=28 (*3*). All are weakly self-fertile (*18*). Seed production varies widely among accessions as shown from a test at Aberdeen, Idaho, where 13 accessions varied from 211 pounds to 660 pounds of seed per acre. The seed is easy to harvest, thresh, and clean. See table 1, appendix, for seed data.

THICKSPIKE WHEATGRASS (*Agropyron dasystachyum*) is the most widely distributed native sod-forming grass in the intermountain region of the Pacific Northwest. It is very common in the upper Snake River area and has been



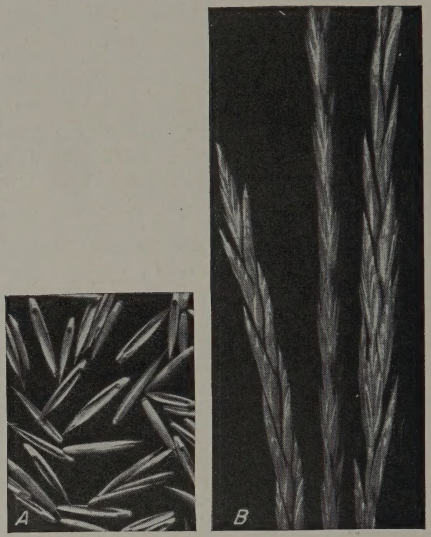
Western wheatgrass plant (x 1/12).



the grass that reproduced a major part of the ground cover on critical watersheds when they were protected against overuse. Once a flood hazard to municipal property, these watersheds no longer have excessive runoff and soil erosion. This grass is being domesticated for use in reseeding abandoned farm lands and denuded ranges in zones 4, 8, and 9.

Thickspike wheatgrass is more drought tolerant than western wheatgrass. It produces good ground cover and satisfactory yields on light-textured soils subject to wind erosion. It begins growth early in the spring and with the first fall rains, thus suppressing cheatgrass. It has the same season of use as crested wheatgrass, and they may be planted and grazed together. In mixed plantings thickspike wheatgrass is also compatible with big bluegrass. Mixed plantings are made in alternate drill rows and are of advantage when the stand of bunchgrass may not be uniform (*20*).

Thickspike wheatgrass does not suffer from plant diseases in the field, but in the nursery leaf rust and stripe rust are common and may be serious. Some strains are more resistant to these diseases than others.



Western wheatgrass: *A*, Seeds (x 1); *B*, heads (x 1).

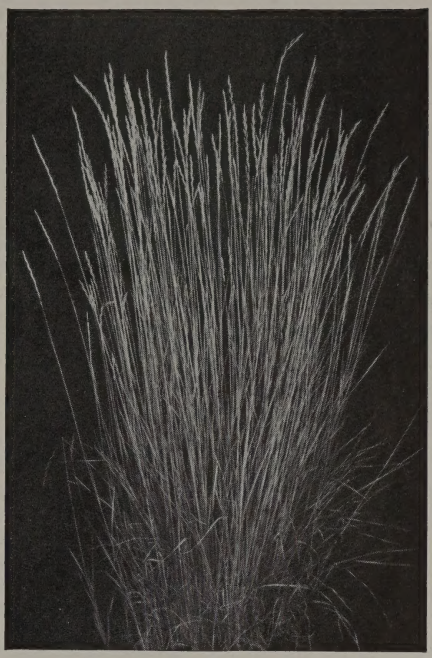
The 56 accessions that have been tested vary in leafiness, seed production, resistance to disease, and total forage yield. The scanty production of seed has detracted from the use of thickspike wheatgrass, but the data from a 1943 irrigated row planting at Aberdeen, Idaho, in the following table show that high-producing strains are possible.

Throughout the area of its greatest natural distribution (that with transitional vegetation between the Palouse bunchgrass prairie and the short-grass prairie), many forms are intermediate between thickspike wheatgrass and western wheatgrass. This suggests that the two species may cross under field conditions. The chromosome number is 2n=28 (*3*).

Accession No.	Yield per acre					
	1944		1945		1946	
	Seed	Forage	Seed	Forage	Seed	Forage
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
P-1822	660	6,019	79	3,432	13	1,940
P-4523	198	2,838	26	2,719	26	1,848
P-4567	449	4,053	145	4,197	106	2,007
P-7803	853	5,306	686	4,672	396	2,548



Thickspike wheatgrass: *A*, Heads (x 1); *B*, seeds (x 1).



Thickspike wheatgrass (x 1/12).

The seed of this grass holds well and may be combined. No special equipment is required to thresh and clean. The amount of hair on the seed varies by strains, but it does not affect the handling of seed in drills. See table 1, appendix, for seed statistics.

STREAMBANK WHEATGRASS (*Agropyron riparium*) is a native sodgrass, but this name does not suggest its use or adaptation. It is very drought-tolerant, the seed germinates quickly, and the seedlings grow fast even when the rainfall is scanty. It produces a more complete ground cover and produces it faster than any other long-lived dryland grass (*20*). Its principal use is for ground cover because the top growth is short and fine and yield for grazing is low. It spreads rapidly by rhizomes but is not weedy. It makes an understory ground cover in mixtures with the dry-land wheatgrasses that provides excellent protection against erosion. It also makes good ground cover when planted alone to protect banks, irrigation canals, and airport surfaces. Its use will be on such sites in zones 4, 6, 8, and 9. There are no important strain differences or serious diseases. Seed production is best from cultivated rows spaced at 36 inches and fertilized with 40 to 60 pounds of nitrogen per acre. An average yield for 3 years has been 200 pounds of seed per acre. Good stands are obtained with a seeding rate of 6 pounds per acre.

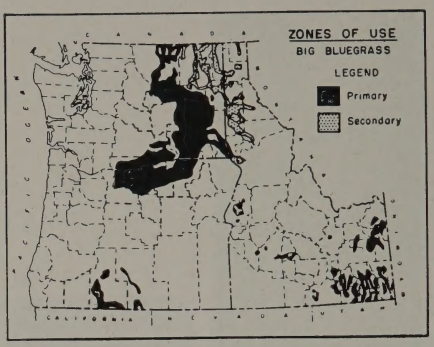
GRASSES OF SECONDARY IMPORTANCE

OTHER DROUGHT-TOLERANT, LONG-LIVED SODGRASSES are *Agropyron elmeri*, a strain of thickspike wheatgrass, and *A. albicans* and *A. griffithsii*, awned forms of streambank wheatgrass.

The extremely vigorous, sod-forming wild-ryes, *Elymus augustus* and *E. pseudoagropyron*, were introduced from Mongolia. Rhizomes with lateral branches penetrated to depths of 3 feet and spread 4 feet per year on Palouse silt loam at Pullman, Wash. This vigorous rhizome characteristic makes these two species undesirable grasses for either cultivated or range areas. They could easily become noxious weeds.

Group 6. Vernal Dominant, Dry-Land Grasses

These native grasses begin growth in early fall, grow rapidly in early spring, and set seed before the soil moisture is used up. They provide ground cover during the runoff season. All of them are valuable range grasses and some can be used for hay and pasture. Big bluegrass is the only one that has been domesticated for conservation use. It is a valuable addition to the list of useful grasses in the intermountain zone of the Pacific Coast States.



GRASSES OF PRIMARY IMPORTANCE

BIG BLUEGRASS (*Poa ampla*) is one of the grasses in the native bunchgrass prairie of the Northwest. It grows well on a variety of soils at elevations of 800 to 6,000 feet in the 10- to 20-inch rainfall zone. It is most prevalent on the loessial soils, but, with its many varieties, it has wide distribution. Under cultivation it is best adapted to zones 3, 4, 6, 7, 9, and 11. It is also well adapted to burned-over land in zones 1 and 5 and to subirrigated meadows in zone 8.

This bunchgrass is long-lived and grows well on depleted soils and in areas with moderate rainfall. Production of hay, seed, and roots is high even where the climate varies from season to season. Yields of hay from a 1940 planting at Lind, Wash., as tabulated below, show this. Many other grasses were in this trial but the three shown were the best. Big bluegrass produced more than the others, especially in the drier years.

Grass and rainfall	Date cut	Yield, dry matter, per acre				
		1941	1942	1943	1944	Average
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Sherman big bluegrass	June 10	1,400	3,670	2,493	1,565	2,282
Crested wheatgrass	June 23	3,124	2,450	1,865	724	2,041
Beardless wheatgrass	June 21	1,577	2,346	1,889	1,062	1,719
		Inches	*Inches*	*Inches*	*Inches*	*Inches*
Seasonal rainfall		13.01	18.00	12.29	9.42	10.40

It was first among 17 grasses at the Tetonia, Idaho, station. This station is at 6,000 feet elevation. The average rainfall is 13.01 inches but varies greatly. The grass was grown in solid seedings and in rows. Half of each field was fertilized at the rate of 50 pounds of ammonium sulfate per acre each fall. The results are tabulated below.

Big bluegrass	Yield, dry matter, per acre			
	Solid seeding		30-inch rows	
	Check	Fertilized	Check	Fertilized
	Pounds	*Pounds*	*Pounds*	*Pounds*
Hay	3,307	4,082	3,768	3,715
Seed	113	113	191	156

Production did not vary much with treatment. The yield of hay was high in all cases. Row seedings produced more seed. The grass is well adapted to conditions at this location. Other trials show that big bluegrass is adapted

to almost all areas where grain-fallow rotations are used. It has been used successfully to reseed abandoned land (*20*).

Mixtures of big bluegrass and one of the wheatgrasses and of big bluegrass and alfalfa are used in conservation seedings. The former mixture is used when rainfall is less than 15 inches. Mixtures with alfalfa are planted where there is more rainfall. Big bluegrass is well adapted to these uses. A typical grass mixture is crested wheatgrass 4 pounds and big bluegrass 4 pounds per acre. An alfalfa-grass mixture contains 5 pounds of alfalfa with 6 pounds of smooth brome and 4 pounds of big bluegrass.

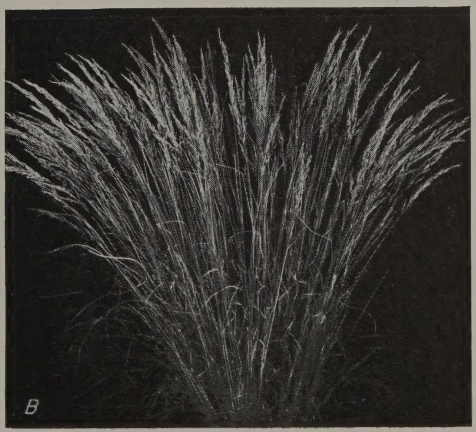
Big bluegrass produces large amounts of fibrous roots even on poorer soils such as are found on class IV and class VI land. This makes it one of the best grasses to use in conservation mixtures. The mixtures are usually used in rotation with grain. When they are plowed the roots improve the soil tilth, raise the organic matter in the soil, and increase the amount of water the soil can absorb. When big bluegrass was grown with alfalfa for 5 years, more than 8,600 pounds of roots (dry) were added to the surface-acre 8 inches. Of this amount

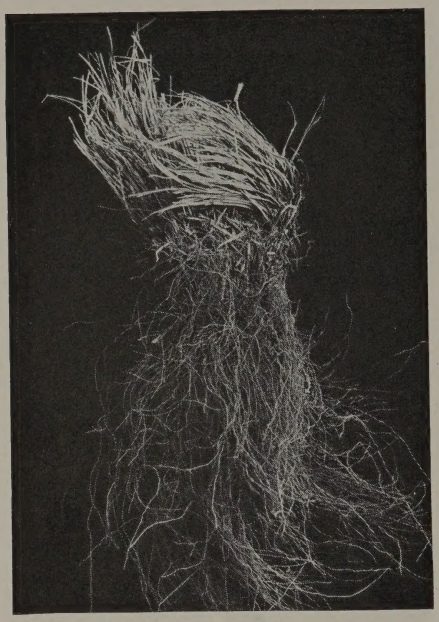


Big bluegrass (x 3/4): *A*, Heads; *B*, seeds.



Types of big bluegrass (x 1/15): *A*, Robust, hay; *B*, general utility.





Roots of big bluegrass.

more than 7,200 pounds were grass roots. Big bluegrass sown alone produced 7,362 pounds of roots on the same eroded soil. Alfalfa alone produced only 2,350 pounds.

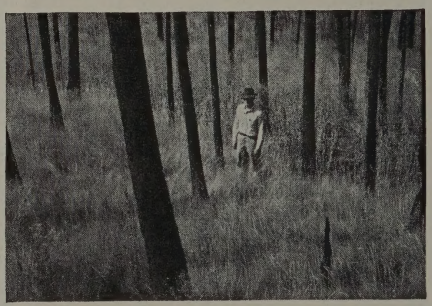
The seed production of big bluegrass is very good. An average production with 18 inches of rainfall is 350 to 400 pounds per acre. Seed crops are grown in 30- to 36-inch rows. The grass is self-fertile; so it is easy to keep a variety pure. Producers of certified seed like this quality.

Big bluegrass hay cures easily and is palatable. Stockmen have harvested hay from native stands for many years. It has been fed to livestock in comparison with other tame grasses and legumes and was found to be as palatable as timothy hay (*13*). It is grazed by sheep and cattle. It is best used for pasture in the early spring because it is even earlier than crested wheatgrass. It must not be grazed the first season after planting or the stock may pull out many of the plants.

The grass has been used with success for seeding burned-over forest land. It has given best results in ponderosa pine areas.

When big bluegrass is used alone for hay it should be seeded in solid stands. Summer fallow provides the best seedbed. The seed is small. It must be drilled very shallow in the fall and not more than ½-inch deep in the spring. When big bluegrass is used in mixtures for pasture, hay, or soil improvement it is seeded in alternate rows with the other grass or the alfalfa. The rate of seeding in solid stands should be not less than 6 pounds and in rows or alternate row legume-grass mixtures 4 pounds per acre.

There are many strains of big bluegrass. They vary in seedling vigor, height, leafiness, color, disease resistance, and yield. The chromosome numbers vary from 2n=62 to 2n=100 (*3*). More than 130 collections from all parts of the Pacific Coast States have been tested. There are 3 general types: (1) Dwarf dry land, (2) general utility, and (3) robust hay. As yet no important use has been found for the dwarf types. The general utility type is now in commercial production. It has been named Sherman big bluegrass. It is the one for which yield data were given. It was selected from a field collection near Moro, Oreg. The hay type is a newer selection from a recent collection. Its ultimate use has not been established except that it is a form that may replace tall oatgrass in the Palouse region. This type is tall, bluish, has large stems, and yields more than the others. Typical plants of these types are illustrated. A comparison between the 2 types is available from a solid planting at Pullman, Wash., as shown in the table on the next page.



Big bluegrass on burned-over land; weeds on unseeded land in background.

Type or variety	Yield, dry matter, per acre					
	1942	1943	1944	1945	1946	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Sherman (general utility)	5, 920	3, 870	3, 310	4, 510	3, 668	4, 256
Robust hay type	6, 980	4, 630	4, 047	4, 365	4, 586	4, 922

The native bluegrasses are susceptible to rust and mildew under semihumid conditions, especially when grown in solid stands or in nurseries. They are not affected as badly in mixed seedings under field conditions. Some hybrids now under test are much less susceptible.

NEVADA BLUEGRASS (*Poa nevadensis*) is very similar to big bluegrass but occurs at higher elevations. It is most common in mountain meadows where it is often utilized as hay. Considerable tonnage of native bluegrass hay is cut in eastern Oregon. Nevada bluegrass is more susceptible to yellow stripe rust than big bluegrass. A second closely related species is alkali bluegrass (*Poa juncifolia*). The chief difference from big bluegrass is that the leaves are rolled and the plants are less robust. It is common in alkaline meadows. Because big bluegrass will do everything these other species will do on cultivated land and do it better, it is the member of the group that is used.



Junegrass (x 1/11).

GRASSES OF SECONDARY IMPORTANCE

SANDBERG BLUEGRASS (*Poa secunda*) is a range grass, found most abundantly on scab rock areas and associated with big sagebrush throughout the intermountain zone. It provides much of the early forage on sheep ranges. Sandberg bluegrass is useful primarily on areas of thin scab rock soils where late-maturing grasses cannot survive. The seed is very small and good seedbeds are needed to establish stands. For this reason it is difficult to plant under range conditions. Canby bluegrass (*P. canbyi*) is a more vigorous and more productive form of Sandberg bluegrass and is associated with it on the more favorable sites.

PINE BLUEGRASS (*Poa scabrella*) is often found with the other species but is usually associated with the open timber on ranges of medium altitudes. It is most abundant on land not subject to



Plant of bulbous bluegrass in full head.

cultivation. These bluegrasses and others are important on native ranges for feed, ground cover, and watershed protection. They all do well under cultivation but cannot match the performance of big bluegrass.

JUNEGRASS (*Koeleria cristata*) is a leafy, palatable, and drought-resistant bunchgrass. The vegetative characteristics favor the use of this species in dry-land agriculture as a pasture plant. Seed production is erratic and never high. Unfortunately, the seed is of low quality, and planting on a field-scale basis under difficult climatic conditions is impractical. Techniques used for planting nurseries and plots guarantee good stands but do not fit farm-size operations.

BULBOUS BLUEGRASS (*Poa bulbosa*) is unique because it can be established by broadcasting on lands too steep or too rough to cultivate. This is possible because the "seeds" are really small bublets that germinate quickly, and the young plants grow rapidly. This naturalized grass grows rapidly in early fall and early spring and sets "seed" early before the soil moisture is depleted. It makes good ground cover when planted alone, and, if the soil is moderately fertile, satisfactory production is obtained. When planted with long-lived grasses on abandoned land, it provides an understory ground cover that controls erosion and retards the volunteering of cheatgrass. It is used in these ways in zone 8 at elevations below 4,000 feet. At high elevations in southeastern Idaho it disappears from the stands in a few years. Even when it is adapted the grass is short-lived, except when it is managed so that it can reseed.

A commonly used mixture is bulbous bluegrass 2 pounds and crested wheatgrass 6 pounds per acre. Such a mixture at Lind, Wash., produced 10 percent more top growth than crested wheatgrass alone. On lands that can be cultivated there are several other grasses that provide more ground cover and produce more roots than bulbous bluegrass. The native bluegrasses, drought-hardy fescues, and streambank wheatgrass have been used in this way. They also keep out cheatgrass. There are several strains of bulbous bluegrass. They vary in vigor, leafiness, total production, and date of maturity. An especially vigorous, leafy, high-yielding strain has been increased.

OTHER VERNAL DOMINANT BLUEGRASSES tested were the native dry-land species *Poa gracillima, P. vaseyochloa, P. cusickii, P. curta,* and *P. epilis.* No agricultural use has been found for them. The following native open timber and alpine bluegrasses were also tested: *Poa fendleriana, P. glaucifolia, P. longiligula, P. nervosa, P. sylvestris,* and *P. glauca.* Important as these bluegrasses are in the native ranges, their low seed viability and scanty seed production have retarded their use in reseeding programs.

Group 7. Understory Grasses With Heavy Root Production

The fine-leaved fescues are excellent understory plants in conservation mixtures on farm land. They are outstanding for their root production. The large quantities of fine roots they produce either when grown alone or in mixtures with legumes improve soil structure. Measured root production in 4-year-old stands has been 5 to 7 tons per surface acre to 8 inches. The leaves are fine, abundant, and dense and the crowns are low so that the plants give good ground cover while they improve the soil. They are able to grow on eroded soils that are low in fertility. These characteristics make them well suited for soil and water conservation.

GRASSES OF PRIMARY IMPORTANCE

IDAHO FESCUE (*Festuca idahoensis*) is a native bunchgrass that is sometimes called blue bunchgrass. It is widely distributed over the area occupied by the Palouse prairie so that many strains occur. It is found from elevations of 1,500 feet to 8,000 feet on a wide diversity of sites. More than 100 accessions have been tested. They vary in vigor, color, width of leaves, and seed production. The tall vigorous types with the longer, wider leaves but with moderate seed production are common in the transition between prairie and timber. The short, densely tufted, narrow-leaved but fertile types are in the open prairie where the rainfall is moderate. Only the tall vigorous types with good seed production have been kept.

Idaho fescue can be grown alone or in mixtures with native wheatgrasses on land-capability class VI in zones 3, 8, and 9. The seedings should be made in alternate rows using 5 pounds of fescue and 6 pounds of wheatgrass. The two grasses can be grazed together because they have about the same season of use in the spring. The fescue provides good grazing in the early fall when it is relished by cattle and sheep.

Seed of Idaho fescue is produced from row plantings spaced 30 to 36 inches apart and cultivated. Six pounds of seed per acre is required. The seed can be combined when in the hard-dough stage. No special equipment is needed to thresh or clean the seed. Seed yields averaged 150 pounds per acre for 3 years.

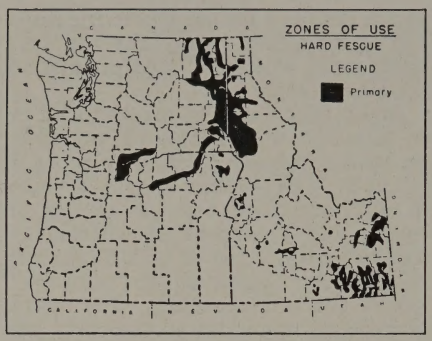
SHEEP FESCUE (*Festuca ovina*) is an introduced grass. Two types have been chosen from more than 40 introductions because they have promise for use in conservation seedings. The first is a hard fescue, *Festuca ovina* var. *duriuscula*, P–2517, and was selected from an old planting in a nursery at Union, Oreg. The second is a sheep fescue, P–274 (P. I. 109,497). The hard fescue has smoother but longer and

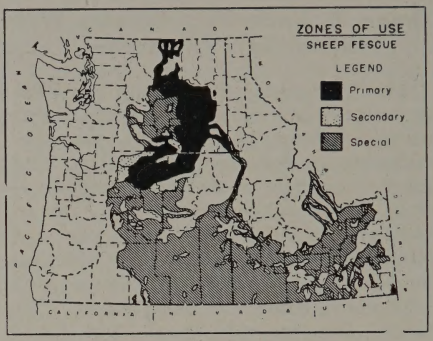


Idaho fescue (x 3/4): *A*, Heads; *B*, seeds.



Idaho fescue (x 1/15).

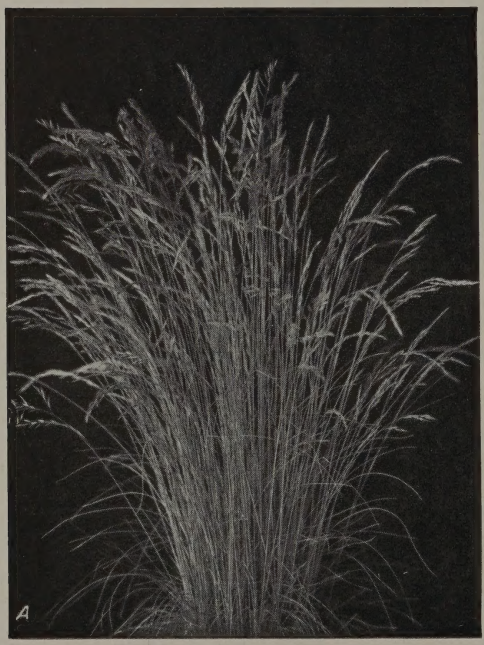




firmer leaves, and the sheep fescue is more drought-resistant. Both grow well on soils that are eroded or low in fertility in land-capability classes IV and VI. The hard fescue is best adapted to zones 1, 2, 5, 7, 9, and 17 and the sheep fescue to 3, 4, 6, and 8. Both are relatively free from diseases.

Hard fescue is very easy to establish. The seedlings are strong and grow rapidly. It can be grown alone or with other grasses but is best when planted with alfalfa. It is an excellent understory plant in mixtures with alfalfa on eroded soils. This is probably its best use. Very little of the top growth gets into the hay, and root production is excellent. In this way ground cover is combined with improvement of soil structure. A good hay mixture is alfalfa 5 pounds and hard fescue 4 pounds per acre planted in alternate rows. When the mixture is to be pastured, 4 pounds of crested wheatgrass may be added.

Hard fescue makes good ground cover and gives satisfactory yields when used to reseed burned-over timberland and overgrazed grassland areas in the ponderosa pine belt in zone 17. It is planted







Hard fescue: *A*, Plant (x 1/15); *B*, heads (x 1); *C*, seeds (x 1).

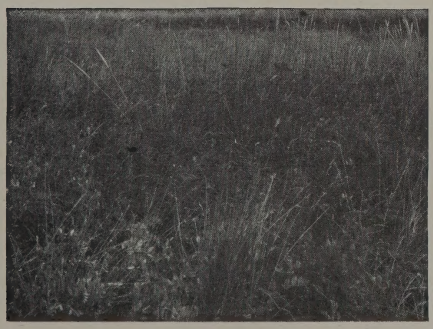
alone or in mixtures with other grasses. Stock show preference for it in early fall and in the spring.

Sheep fescue, P–274, is more drought-resistant than hard fescue. Its production is lower, but it makes good ground cover and is high in root production. It can be used with the wheatgrasses in alternate row seedings in areas of low rainfall. In such mixtures 4 pounds of sheep fescue is used with 5 to 6 pounds of wheatgrass. It is adapted to bank stabilizing along lined irrigation canals and for road cuts and fills.

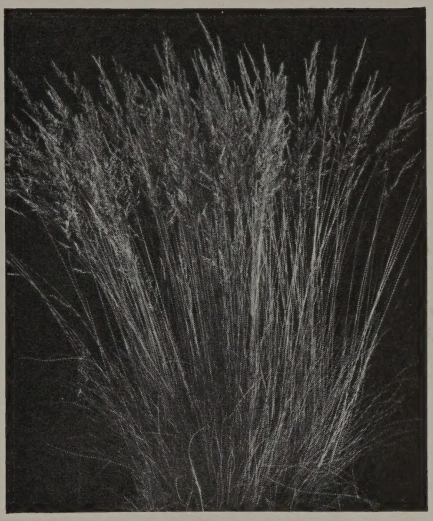
Hard fescue and sheep fescue are good seed producers, yielding an average of 500 and 300 pounds per acre, respectively, from row seedings on good soil. The seed is combined when it is in the hard-dough stage. No special equipment is needed for cleaning. Both grasses are weakly self-fertile (*18*). The seeds of both these fescues are small and require good seedbeds and shallow coverage when they are planted. They are seeded in the fall, except when used with alfalfa.

THE RED FESCUES (*Festuca rubra*) are either bunchgrasses or sodgrasses, but both produce a large amount of fine tough roots. Red fescues are used for erosion control on steep slopes, road cuts, waterways, burned-over forest land, and sand dunes. Adaptation and use depend on the variety or strain that is grown.

Chewings fescue (*F. rubra* var. *commutata*) is a bunchgrass. It is widely used for turfing but makes a good ground cover on steep slopes and burned-over forest land on land-capability class VI in zones 14 and 16. Seedings on burned-over land have been grazed.



Clatsop red fescue in a mixture for permanent control of sand dunes.



Sheep fescue (x 1/12).

There are many strains of creeping red fescue. They vary in length of rhizomes, width of leaf, color of foliage, and production. The broad-leaved, spreading type is the most useful in conservation mixtures. A mixture of creeping red fescue 4 pounds, Akaroa orchard grass 4 pounds, Tualatin oatgrass 4 pounds, and Tallarook subterranean clover 5 pounds per acre is used on land-capability classes IV and VI in zones 12 and 16. These uplands are steep and the soil is low in fertility, but the mixture provides good ground cover and is used for pasture.

Clatsop red fescue was selected from the native vegetation on the coastal dunes of Oregon. It is distinct for its seedling vigor, long leaves, early spring recovery, fall recovery, and growth during the warm summer and the cool winter months. These qualities make it especially useful for the permanent cover on sand dunes after the erosion has been stopped. It does not become sod-bound as quickly as many other strains of creeping red fescue. At Warrenton, Oreg., yields of vegetal cover and seed were the best among 26 accessions. Data for Clatsop red fescue and 2 other typical strains from seedings made in 1941 are shown in the table on the following page.

Strain	Yield per acre							
	Seed				Total dry matter			
	1942	1943	1944	Average	1942	1943	1944	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Clatsop	631	588	632	617	2,722	2,904	2,360	2,662
Common	0	44	30	30	1,720	908	90	906
German	430	0	230	220	4,261	1,677	726	2,221

Because Clatsop red fescue remains green through the summer months it reduces the fire hazard on the dunes. A good mixture for permanent seedings on the coastal dunes in zone 18 is Clatsop red fescue 4 pounds, common ryegrass 6 pounds, purple beach pea 20 pounds, and hairy vetch 30 pounds per acre. The new seedings are benefited by an application of 300 pounds per acre of 16–20–0 fertilizer.

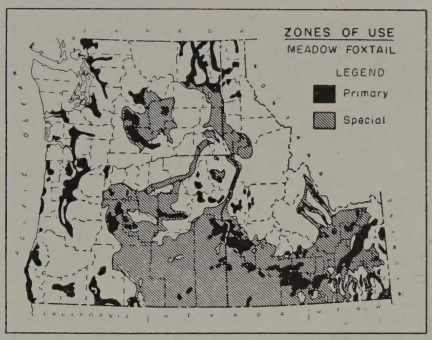
OTHER UNDERSTORY GRASSES are the southern *Festuca arizonica, F. viridula* that resembles Idaho fescue, and the annual fescues *F. megalura, F. myuros, F. octoflora,* and *F. pacifica. F. arizonica* is not adapted in the north and *F. viridula* produces seed of low quality when cultivated. The annual fescues are small, weedy, and low in production. They require favorable conditions for reseeding and succumb to competition from cheatgrass and weeds.



Clatsop red fescue (x 1/12).

Group 8. Wet-Meadowland Grasses

Wet-meadowland grasses grow well on soils with a high water table. They withstand prolonged periods of flooding, especially in the winter and early spring. Established stands are moderately tolerant to summer drought in subhumid zones. Seed habits are poor and this has retarded use.



GRASSES OF PRIMARY IMPORTANCE

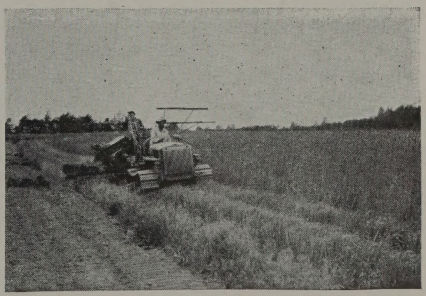
MEADOW FOXTAIL (*Alopecurus pratensis*) AND CREEPING FOXTAIL (*A. arundinaceus*) are similar in their adaptation and use. They are used as pasture on land-capability classes II, III, and IV in zones 5, 10, 11, 13, and 14. They are used on wet, class IV land in zones 2 and 8. Adaptation is especially good to the brackish conditions of tideland pasture and to river bottoms subject to overflow in zone 14. A foxtail-lotus mixture produced 1 ton more than an adjacent field containing ryegrass, orchard grass, and clover on river bottom land. The foxtail stand was in excellent condition after 4 years of repeated flooding. The other mixture was so poor it was plowed out.

The foxtails are palatable grasses with a high percentage of leaves. In trials at Union, Oreg., foxtail cut at the hay stage averaged 52.5 percent leaves, the second highest of 22 grasses. Palatability to sheep was 93 percent when pastured and 86 percent when fed as hay, making it 1 of the 5 best grasses tested. The protein content of the hay averaged 9.90 percent, the highest of all grasses in the test (*13*). Total production under subirrigated alkaline conditions is less than other grasses in this group, indicating less tolerance to high concentrations of alkaline salts. This has been verified (*14*).

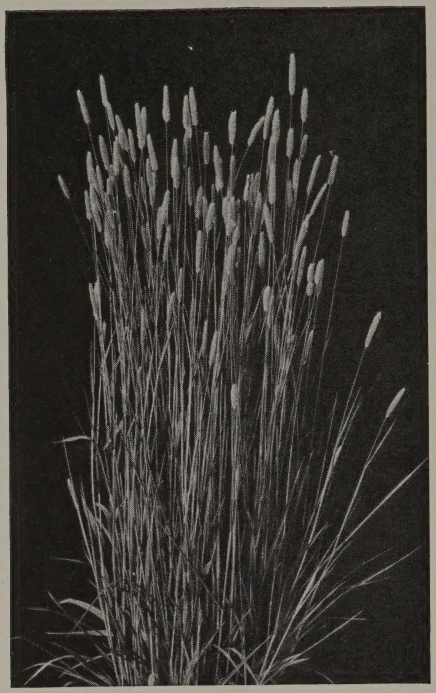
These grasses grow during the winter, early spring, and into the summer under the mild climatic conditions west of the Cascade Mountains. They begin to bloom early in the spring and continue to head and seed into midsummer or as long as moisture is available. Seed harvest is in late June at Bellingham, Wash. The crop is bound, shock-cured, and threshed. Seed is difficult to harvest because it shatters, and threshing and cleaning are complicated because the seeds are light, fluffy, and hairy. When proper precautions for harvesting are taken, seed yields have averaged 200 pounds per acre from row plantings fertilized with 40 pounds of nitrogen per acre. These values are based on a good strain of creeping foxtail. Details for harvesting by other methods have been printed (*14*). Seed is hard to plant, but it can be processed with a hammer mill to



Foxtail in mixture on wet meadow (right) compared with orchard grass (left).



Seed of foxtail is harvested by binding at Bellingham, Wash.



Plant of creeping foxtail (x 1/12).

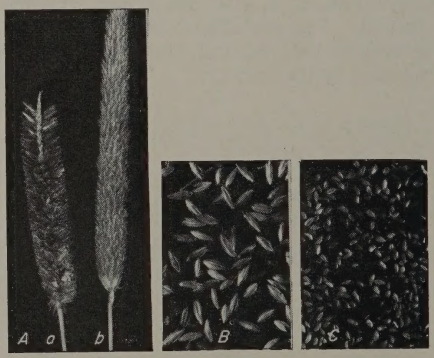
make it easier to handle. If much of the seed is hulled it should be planted soon after processing, or germination will decline rapidly. Processed seed can be planted with a drill.

There are wide variations among and within the 44 accessions of foxtail that have been tested. They can be grouped only by species. The common meadow foxtail (*A. pratensis*) has awned seeds that are predominantly white, and it has weak rhizomes. Creeping foxtail (*A. arundinaceus*) has awnless seeds, vigorous rhizomes, and seeds that tend to be black. Many accessions of creeping foxtail have been introduced, but the best one has been P. I. 110,067.

Excellent seedbeds are needed to get good stands of meadow or creeping foxtail. Seedings are made in the late spring on wet meadowlands. The seedlings are weak during the first season, will not stand competition from heavy weed growth, and should not be grazed. Good meadows result from planting 5 pounds of foxtail with 4 pounds of birdsfoot trefoil per acre. On tidelands 2 pounds of big trefoil are used instead of birdsfoot trefoil. Applications of fertilizers containing 60 pounds of available phosphate are beneficial to the trefoil. A satisfactory mixture for irrigated pasture in zone 10 is creeping foxtail 5 pounds, perennial ryegrass 3 pounds, and Ladino clover 2 pounds per acre. Statistics for seed are given in table 1, appendix.

REED CANARYGRASS (*Phalaris arundinacea*) is a well-known wet-meadowland grass. It will stand more deep-ponded water than the other grasses in this group, especially during the winter and early spring. It produces high yields on overflow or swampy lands if the soil has good fertility. Its adaptation is to wet lands in land-capability classes IV and V in zones 1, 5, 10, 13, and 14. Plantings of reed canarygrass along gullies and small streams are effective in controlling bank erosion, but they may catch enough silt to change the channel unless grazed or clipped. It is only moderately tolerant to alkaline soils.

Reed canarygrass is tall, coarse, and stemmy and is best used for pasture. Pastures should be grazed reasonably close or regularly clipped so that there is no excessive growth that gets old and tough. The grass makes good silage. Although the percentage of leaves was high and the percentage of protein average, the hay was least palatable among 22 grasses in a 4-year test at Union, Oreg. (*13*). No differences were



A, Heads of foxtail: *a*, Creeping foxtail (x 3/4); *b*, meadow foxtail (x 3/4); *B*, threshed seeds of creeping foxtail; C, processed seeds of creeping foxtail.

found among 35 accessions of reed canarygrass. Strain differences exist but are not important.

Seed of reed canarygrass shatters badly and is hard to harvest. It can be grown on good cultivated land in semihumid areas. Here it can be bound and shocked or harvested with headers and dried on canvas. It should be bound or headed when the seed is in soft dough. Threshing and cleaning present no special problems. Seed yields are variable, but an average of 250 pounds per acre has been obtained at Pullman, Wash.

The seed of reed canarygrass is easy to handle. It germinates slowly and the seedlings are weak. Good seedbeds are necessary to reduce competition from weeds and to insure a uniform shallow depth of planting. Drilling is better than other methods of seeding on cultivated land, but the seed must not be planted more than 1 inch deep. Plantings along streams and wet gullies can be made from sod chunks.

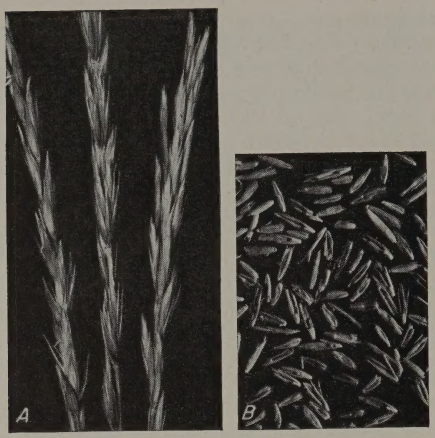
BEARDLESS WILD-RYE (*Elymus triticoides*) meadows are common on wet alkaline soils of land-capability class V in zone 8 and where these conditions are found in zones 9, 10, and 11. No other native, commercial, or introduced sodgrass makes a better cover or yields more under these conditions. Ranchers harvest an excellent quality hay from the meadows. Hay was rated as moderately palatable to sheep and similar, in this respect, to tall oatgrass at Union, Oreg. (*13*). The foliage remains green into late summer even after a seed crop has been produced. Strawberry clover has invaded some stands of beardless wild-rye, and the 2 plants make an excellent mixture.

Beardless wild-rye has been tested extensively in the nurseries. These tests have verified its tolerance to wet alkaline soils and have shown that established stands make good ground cover and good yields on light-textured soils under semiarid conditions in zone 3. Good stands are obtained on class IV land if the plantings are made in rows and cultivated for 1 or 2 years. The seed germinates slowly in the field, and the young plants do not compete with weeds, weedy grass, or other cultivated grasses. Solid seedings in 6-inch drill rows developed normal stands at Pullman, Wash., when treated with dinitro sprays to reduce competition from annual weeds. The treated stand was 50 percent greater than the untreated and in the second year was 4 times as vigorous. There is evidence of delayed germination in the seed, and treatment with potassium nitrate has increased the rate of germination 2 to 3 times for some strains. Germination has improved with age of seed, increasing in one case from 5 percent the first year to 86 percent the sixth year when stored in the warehouse.

Wide variation occurs among the 60 accessions of beardless wild-rye that have been tested. They differ in height, leafiness, yield, vigor of rhizomes, and in quality of seed. Two principal types occur: (1) Tall, coarse, leafy, vigorous rhizomes, fair seed production; and (2) short, fine stems, narrow leaves, small heads, poor seed production. The first type has been more promising.



Plant of beardless wild-rye (x 1/12).



Beardless wild-rye: A, Heads (x 3/4); B, seeds (x 3/4).

Beardless wild-rye is weakly self-fertile (*18*). Seed production from stands on cultivated land has been low, averaging 60 pounds per acre for 4 years, but in some years they produce as much as 175 pounds. It can be combined and this is the method used when harvesting from native stands.

Strains of beardless wild-rye vary in resistance to leaf rust, stripe rust, and ergot. Some strains are especially susceptible to rust, and in some years infection of ergot is high and is responsible for the grass being locally referred to as "honey grass." Ranchers maintain that stock show no ill effects from consuming large amounts of ergot-infected material.

Because of its special adaptation to adverse soil conditions, strains of beardless wild-rye should be found or developed that are free from diseases and easy to culture. It could replace low-quality grasses and other poor forage so common on poorly drained alkaline soils.

GRASSES OF SECONDARY IMPORTANCE

REDTOP (*Agrostis alba*) can be used on low wet areas, especially if the soil is acid to neutral. It has been used in mixtures for waterways and for gully stabilization in zones 1, 2, 5, 7, and 9. The seed is small, and a good seedbed and shallow seeding are necessary to get good stands. Once redtop is established, its low spreading growth makes a good ground cover for a waterway. Redtop is adapted to soils low in fertility, as is often the case with gullied areas and low wet sites. An established stand will endure summer drought. It should always be planted with one of the rapid-developing grasses and alsike clover for protection to the waterway during the first season. Failure to get good stands of redtop has been due to the fact that the seed contained bentgrass that is not adapted to these zones.

OTHER WET-MEADOWLAND GRASSES have been inferior to the four grasses already mentioned. *Alopecurus alpinus, A. aequalis, A. geniculatus,* and *A. pallescens* are native foxtails that have been less productive than meadow foxtail. The hairgrasses, *Deschampsia caespitosa* and *D. elongata,* are common on low wet areas. *D. caespitosa* produces a coarse basal foliage, seeds well, is not palatable, but offers no promise for domestication. The smaller *D. elongata* is short-lived. The slough grasses, *Beckmannia syzigachne* that is native and the introduced *B. erucaeformis,* along with the mannagrasses, *Glyceria grandis, G. pauciflora,* and *G. striata,* seed abundantly and volunteer in low wet places but require more moisture than is usually available on cultivated land. The native barley grass (*Hordeum nodosum*) and the introduced *H. brevisubulatum* do well on wet sites, but the seed shatters badly and this prevents domestication.

Salt grass (*Distichlis stricta*) is common throughout the interior of the Northwest on alkali flats. Many strains have been tested, but seed production is very poor and the quality is low. Vegetative propagation for this and for alkali cordgrass (*Spartina gracilis*) is required.

For cultivated land that may be wet during the winter months, mention must be made of the adaptation of tall fescue. Western wheatgrass does well if flooded or inundated for short periods in the winter, even if the soil is moderately alkaline. It will not endure the long periods of flooding or the high alkali concentrations to which smooth wild-rye is adapted.

Group 9. Sand-Stilling Grasses

These grasses are used to stop drifting sand. They have coarse, stiff stems and tough leaves that resist sand blasting. Well-developed stems are transplanted in hills on the bare sand because seedlings would be blown out before they were established. The transplants are set out according to a pattern that stills the sand (*9*). They grow and stool to form a protecting cover even though large amounts of sand accumulate. They are easy to propagate in nurseries for transplanting to the dunes.

The sand-stilling grasses of primary importance are not palatable to livestock. This is an advantage because any reduction of the plant cover on sandy areas causes blow-outs that soon become larger and create an erosion hazard.

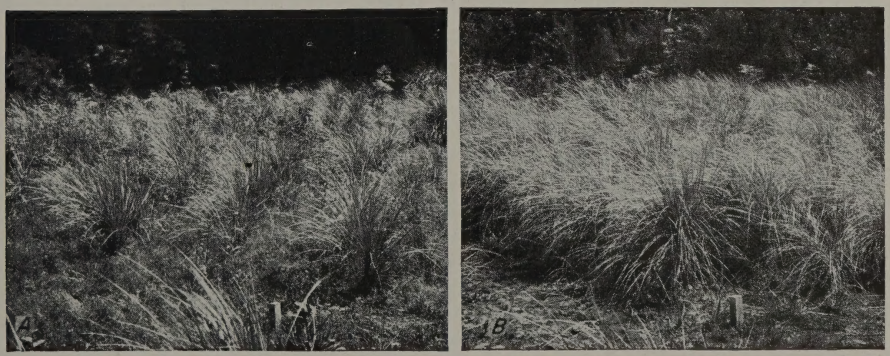


European beachgrass plant (x 1/15).

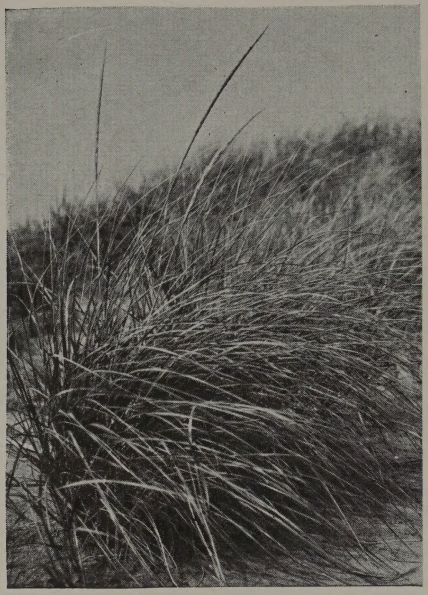
GRASSES OF PRIMARY IMPORTANCE

EUROPEAN BEACHGRASS (*Ammophila arenaria*) is naturalized on the Pacific coast, where it has been used to control sand dunes since 1896. It is best adapted to coastal conditions in zone 18 but has been used to control sand drifting in zone 4 and the inland areas of zone 18. This grass stops growing when the sand is stilled, and then other grasses must be planted into the beachgrass stand.

There are 4 types of European beachgrass: (1) Tall, coarse, and bunchy; (2) tall, coarse, and creeping; (3) short, fine, and bunchy; and (4) short, fine, and creeping. The creeping types do not have long rhizomes. The strains in each type differ in the rate of stooling. Field-run material increases at the rate of 13:1 during the first year, while one selected strain increases at the rate of 120:1. The number of culms (stems) per pound varies from 58 for coarse types to 117 for fine types. The best strain for dune control is one of the tall, coarse, creeping types that increases at the rate of 40:1 and has 85 culms per pound.



Strains of European beachgrass differ in the rate of increase: *A*, Increased at the rate of 13: 1; *B*, increased at the rate of 120: 1.



American beachgrass plant (x 1/15).

European beachgrass gives the best dune control under average conditions when planted with 5 culms per hill with 18 inches between hills. It can be transplanted at any time that the maximum air temperature is 55° F. or lower. This is from early fall to late spring. The plantings should be fertilized with 40 pounds of nitrogen per acre, preferably as an ammonium salt. They continue to grow as long as sand accumulates, but they deteriorate once the sand is stilled. Seedings of perennial grasses and legumes or plantings of shrubs and trees must be made to provide permanent erosion control.

AMERICAN BEACHGRASS (*Ammophila breviligulata*) spreads by rhizomes, is less sensitive to air temperature, and is longer lived than European beachgrass. The best strain produced 396 feet of rhizomes in 6 months, while the strongest creeper of European beachgrass produced only 57 feet of root stalks. American beachgrass can be transplanted any time except in the driest summer months because it is not sensitive to high temperature following planting.

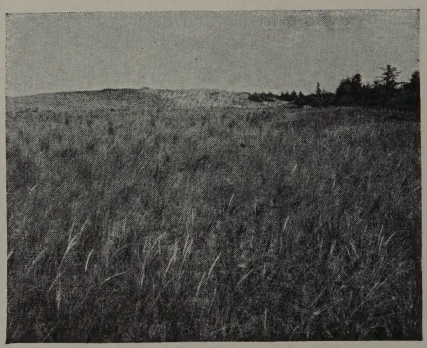
American beachgrass is adapted to the control of drifting sand on the coast. It has greater usefulness than European beachgrass because it has a long planting season and it lives longer. Plantings should be made in the same way as for European beachgrass and should be fertilized. Permanent vegetation must be planted as for European beachgrass but not as soon.

The grass has the same types as European beachgrass. The best strain has been called Talriza and is a tall, coarse, creeping type. It was selected from the native vegetation on the Oregon coast. It was the best among 20 strains assembled from the Pacific coast, the Atlantic coast, and the shores of the Great Lakes.

MAMMOTH WILD-RYE (*Elymus giganteus*) was introduced from Siberia. Several strains were obtained, but only one has been adapted. It is especially useful for the control of inland sand



Planting pattern for sand-stilling beachgrass spaced 18 inches apart.



Beachgrass makes a complete cover in 1 year when fertilized.



Volga wild-rye controls an inland sand dune.

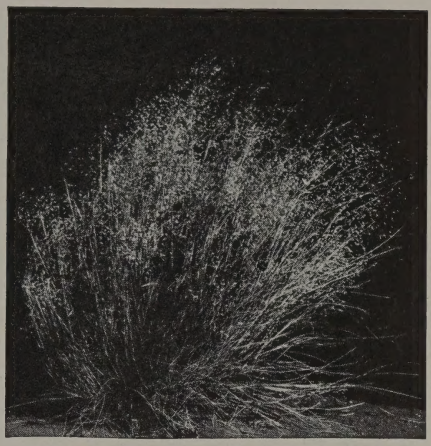
dunes in zone 18 and, where active sand occurs, in zones 3, 4, and 8. It is not adapted to coastal conditions. This strain (P. I. 108,491) has been named Volga.

Volga wild-rye is a tall, coarse, creeping grass that is not palatable to livestock or to rabbits and is long-lived on inland dunes. It not only stills the sand but continues to grow and provide the permanent cover on the dunes. This is not true of other sand-stilling grasses or of the other strains of this wild-rye.

Volga wild-rye is transplanted in the same way as are the beachgrasses. It responds to nitrogen fertilizers if the rainfall is more than 12 inches. In the propagation nursery the plants can be grown from seed or from transplanted culms. The rate of increase from culms is 15:1 in the first year.



Volga wild-rye plant (x 1/12).



Indian ricegrass plant (x 1/12).

GRASSES OF SECONDARY IMPORTANCE

INDIAN RICEGRASS (*Oryzopsis hymenoides*) is an inland species that can be established by planting clones only if there is little surface movement of the sand. Once established on sandy lands it spreads quickly, makes a good cover, and provides good forage. Its value for such sites has long been recognized, but seedings have not been successful because the seed has a persistent delayed germination. This has been partially solved by finding a strain that has an average of not more than 50 percent hard seed. This strain is designated as P–2575 and was one of the 152 accessions of ricegrass collected from the native vegetation.

OTHER SAND-STILLING GRASSES are the dunegrasses *Elymus mollis* and *E. vancouverensis* and sea lymegrass (*E. arenarius*), but they are inferior to the beachgrasses. Adapted to inland dunes but inferior to Volga wild-rye are the native wild-ryes *E. arenicola* and *E. flavescens*, the introduced wild-ryes *E. dasystachys* and *E. sabulosus*, the sand reedgrasses *Calamovilfa gigantea* and *C. longifolia*, blow-out grass (*Redfieldia flexuosa*), and *Calamagrostis epigeios*. The dropseeds, *Sporobolus asper*, *S. airoides*, *S. cryptandrus*, and the native ricegrasses *Oryzopsis bloomeri* and *O. webberi* are inferior to Indian ricegrass, as are the more southern introductions *O. miliacea*, *O. holciformis*, and *O. coerulescens*.



A plant of birdsfoot trefoil (x 1/8).

Group 10. New Legumes

A large number of native and recently introduced legumes have been tested to determine their value for soil conservation. Those reported herein show considerable promise based on nursery tests and field demonstration plantings. Seeds of only a few species are available commercially. Special attention was given to those that might be useful on severely eroded soils, under semiarid conditions, and on depleted range lands. Common legumes have not given good results under these conditions.

Many legumes are used in conservation work in the Pacific Northwest. They are usually grown in mixtures with grasses in the subhumid areas and under irrigation. They include the perennials, alfalfa and white, alsike, strawberry, and Ladino clover and the biennials, red clover and sweetclover. Common and hairy vetch and Austrian field peas are annuals used for cover crops and green manure. These legumes are well known and require no discussion.

LOTUS is an introduced legume that thrives on soils that are too shallow, too wet, or too acid for alfalfa and produces more than white clover on low-fertility upland soils. Seed is hard to harvest because *Lotus* shatters badly, but good crops can be grown in the Northwest if care is exercised when harvesting.

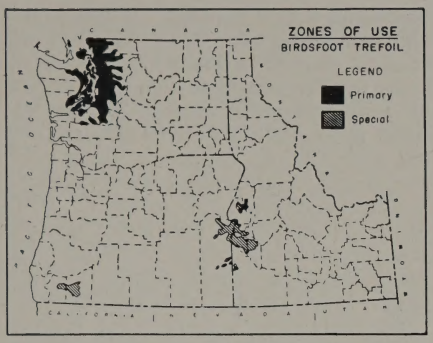
BIRDSFOOT TREFOIL (*Lotus corniculatus*) is an introduced legume that is used in grass-legume mixtures on bottom land and foothill soils of land-capability classes I to IV in zone 16 and zone 14 in Washington, and for specialized areas in zone 10. It has a shallow taproot and produces many fibrous roots.

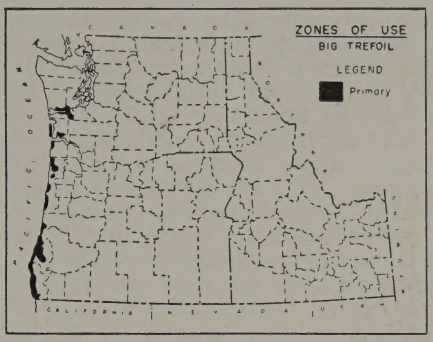
The value of birdsfoot trefoil depends on the strain that is used. There are several strains that can be grouped into 2 general types. One has narrow leaves and is prostrate and the other has broad leaves and is erect. Some regard the first as a distinct variety or species (*8, 24*). A total of 40 accessions of the 2 types have been tested, and the erect, broad-leaved type has been more productive. The strains of this type vary in seedling vigor, coarseness, date of maturity, and production.

A selected broad-leaved strain of birdsfoot trefoil has been equal to alfalfa in yield at Bellingham, Wash., on land-capability class III as is shown from the data below, taken from a 1941 planting. The production of the trefoil in the first year was especially good.

Mixtures of grass and birdsfoot trefoil are used for pasture, silage, or hay. A good pasture mixture is creeping foxtail 5 pounds and birdsfoot trefoil 4 pounds per acre. A good hay or silage mixture has been Akaroa orchard grass 4 pounds and birdsfoot trefoil 4 pounds per acre. The pasture mixture is used on land with a high water table, and

Legume	Yield, dry matter, per acre					
	1941	1942	1943	1944	1945	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Birdsfoot trefoil, P–13659	5,100	9,525	10,491	9,692	7,213	8,404
Alfalfa	2,210	10,880	9,185	10,020	7,690	8,197



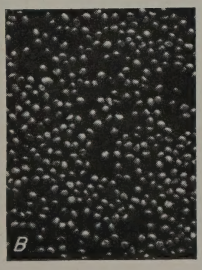


the other mixture is used on upland soil. Sometimes Alta fescue at 6 pounds per acre is added to these mixtures.

Birdsfoot trefoil responds to applications of phosphate fertilizer, but care must be used in applying the fertilizers to mixed seedings. If too much is used, the grass crowds out the legume. The fertilizer is especially useful when a new stand is being established. When birdsfoot trefoil is planted, the seed must be inoculated with cultures especially prepared for this legume. Young seedlings tend to grow slowly in a new planting, but the selected strain has exceptional seedling vigor.

Seed is produced best from row plantings in which 36-inch spacing and 3 pounds of seed per acre are used. The crop is cut when the upper pods begin to shatter. It should be mowed in the early morning when the pods are tough and should immediately be bunched into small piles. Even so, seed will shatter as the crop dries, and much seed can be saved by putting the cocks on paper or canvas. No special equipment is needed to thresh, but disk and gravity machines are important for cleaning. Yields of seed vary among strains, but a good strain will average 150 pounds per acre. Statistics for seed are given in table 1, appendix.





Birdsfoot trefoil (x 3/4): *A*, Pods; *B*, seeds.

Big trefoil (*Lotus uliginosus*) is used in pasture mixtures on tidelands or other low wet areas in zone 18 and in zone 14 in Oregon and southwestern Washington. It is a long-lived legume that spreads by means of shallow rhizomes. Its adaptation to low, wet, and brackish land is unique among pasture legumes. A good mixture for such areas is creeping foxtail 5 pounds and big trefoil 2 pounds per acre.

Two distinct types of big trefoil are recognized: hairy-leaved and smooth-leaved. A total of 20 accessions have been tested, and 3 of these were of the smooth-leaved type. Good strains of the 2 types do not differ in production or amount of ground cover, but the hairy type produces more seed.

Seedling vigor of big trefoil is only fair but is greatly benefited from the application of phosphate fertilizers. A specific inoculant is required. The new stand should be grazed very carefully, if at all, during the first season so that the plants can become well established.

Seed production is more difficult than with birdsfoot trefoil because seed is usually harvested from a mixture that is used for early season pasture. Best results are obtained when the stand is grazed until late June, clipped, and then harvested in late summer. Foreign seeds are numerous in the material from mixed stands, and special machinery is needed to clean the trefoil properly. The seed of big trefoil

is much smaller than that of birdsfoot trefoil, as is shown in table 1, appendix. Yields have averaged 150 pounds per acre for the hairy types and 50 pounds for smooth strains.

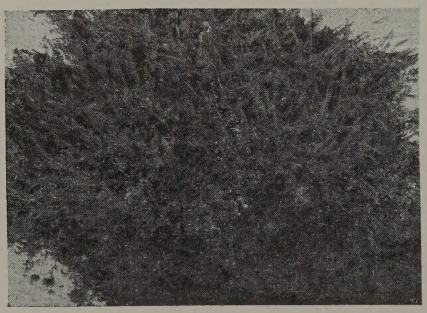
THE MILKVETCHES show promise of supplementing alfalfa in conservation seedings. They are introduced legumes that are large-seeded and more productive than the native milkvetches. They are more frost-hardy and drought-tolerant than alfalfa. Although many of the milkvetches contain highly toxic alkaloids, neither the young growth nor the cured hay of those used in this work contain alkaloids, nor do the plants accumulate selenium in amounts that are toxic to livestock.[3] The milkvetches produce high yields of seed even in areas where alfalfa fails to seed. The seed is very hard and scarification is required. The young seedlings grow slowly, and the plants require 2 to 3 years to reach full production; therefore, young stands require cultivation or protection from grazing.

Cicer milkvetch (*Astragalus cicer*), P. I. 66,515, is a perennial sod-forming legume with a spreading growth and succulent stems. It is 2 or more weeks later in early spring growth and in blooming than alfalfa and holds its leaves well when the soil moisture is low. It recovers well after clipping or grazing and is remarkably free from diseases and insect damage. It has probable use in legume-grass seedings on shallow soils or in areas where rainfall is too low for alfalfa in zones 3, 6, and 9 on land-capability classes IV and VI. Seed production averages 300 pounds per acre. Seven accessions have been tested and no differences were noted.

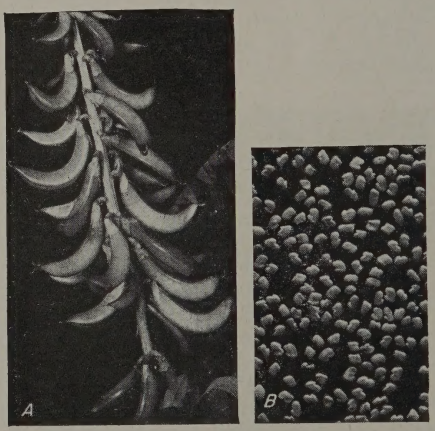
Sickle milkvetch (*A. falcatus*), P. I. 66,440, is taprooted, with erect growth and fibrous stems. It is frost-hardy at high elevations where alfalfa is damaged. It has been used in pasture mixtures with smooth brome and crested wheatgrass on land-capability classes III and IV in zone 9. Spring growth is similar to alfalfa, but the plants bloom earlier and mature later than alfalfa. This legume will remain green until late August when moisture is available but sheds its leaves when the soil moisture is depleted. Production is equal to alfalfa and seed production is exceptional, averaging more than 1,000 pounds per acre under irrigation. The pods are tough and difficult to thresh, but this difficulty can be overcome by running them through a hammer mill at one-half the normal speed of the mill. Sickle milkvetch is sometimes infected with mildew and aphids. No difference has been found among the eight accessions tested.

SUBTERRANEAN CLOVER (*Trifolium subterraneum*) is an introduced legume. This winter annual clover is being used to provide a better erosion-controlling cover on many hill lands and for pas-

[3] The authors are indebted to Ward T. Huffman, Bureau of Animal Industry, U. S. Department of Agriculture, Salina, Utah, for alkaloid determinations and to H. G. Byers, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, Washington, D. C., for selenium determinations.



Sickle milkvetch.



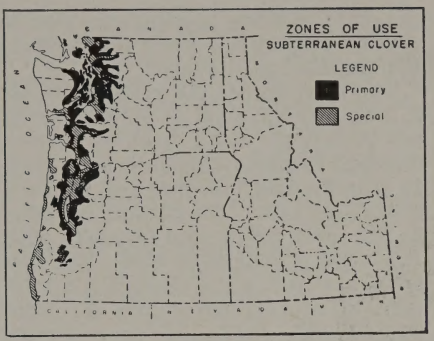
Sickle milkvetch (x 3/4): A, Pods; B, seeds.

ture improvement on land-capability classes IV and VI in zones 12, 13, 14, and 16.

Subterranean clover will thrive in moderately acid to neutral soils. It is less adapted to soils of a high lime content. Applications of phosphate fertilizer must be used if the clover is to reseed itself and provide adequate cover for erosion control and feed. Natural reseeding is necessary to maintain a stand because this clover is an annual.

Seed harvest is a problem. Seed heads develop on prostrate stems. When the seed is forming the heads push to the soil surface with many burying themselves. To get this seed, special lifter fingers must be used on the mower to raise as many of the seed burs as possible to where they can be harvested. On light, loose soils most of the burs growing underground hang to the plant as it is lifted by the fingers. A large part of the seed crop on heavy, hard soils may be lost. The heavy soils may have been moist when the burs formed and turned down into the soil, but may dry and harden before the burs mature. Hulling the seed from the burs requires double threshing or special adjustments of the thresher. Instructions for harvesting seed have been published (*12*).

There are wide differences in the



strains of this clover. The 45 accessions tested in Soil Conservation Service Nurseries are grouped according to date of maturity into (1) very early, (2) early, (3) midseason, or (4) late. Seed-coat color of the important varieties is some shade of purplish black.

The late-maturing strains represented by Tallarook are the best adapted for use in zones 14 and 16. They will produce good crops and reseed themselves. The midseason strains represented by Mt. Barker are adapted in zones 12 and 13 and as far north as Chehalis, Wash., in zone 14. They do not reseed well in zone 16 and the northern part of zone 14, as is shown by the following data from upland pasture mixtures at Bellingham, Wash.

Strain	Percentage of stand found to be subterranean clover		
	1943	1944	1945
	Percent	*Percent*	*Percent*
Mt. Barker (midseason)	11.01	6.00	7.70
Tallarook (late)	16.83	49.80	43.40

Early and very early strains do not produce as much cover as the later strains in this area. They are best adapted to localities having an extremely short season when moisture is present.

A typical mixture for land-capability classes IV and VI is subterranean clover 5 pounds, creeping red fescue 4 pounds, orchard grass 4 pounds, and perennial ryegrass 3 pounds. This clover is popular on these poor lands because it improves the growth of plants with which it grows. Widespread availability of seed certified as to variety will make this plant more valuable, especially in areas where all strains are not adapted.

PURPLE BEACHPEA (*Lathyrus maritimus*) is a native perennial legume that spreads by rhizomes. It is especially abundant on the immediate coasts of Oregon and Washington. It is used in the grass-legume mixture that is seeded into the sand-stilling grasses to provide the permanent cover on coastal dunes in zone 18. No other legume is better adapted to this use than purple beach-

pea, but the young seedlings are slow to develop and do not reach full production until the third season.

The most successful mixture for use in dune stabilization is purple beachpea 20 pounds, hairy vetch 30 pounds, common ryegrass 6 pounds, tall fescue 10 pounds, and creeping red fescue 4 pounds per acre. The mixture is seeded in the early spring and fertilized with 150 to 200 pounds of 16–20–0. The ryegrass and vetch are used in the mixture to provide cover and nitrogen, respectively, until the slow-growing beachpea and the other two grasses are established.

Purple beachpea produces a good seed crop in the grass-legume mixtures on the dunes but does not make a good crop when planted alone. Harvest is from mixed stands that are mowed, bunched, and threshed. The peas can be separated from the seed mixture. The hard-seed content of purple beachpea ranges from 15 to 70 percent, depending on the season, but scarification is not required.

Purple beachpea is palatable to livestock, and this is a disadvantage in dune-control work. Infection by pea moth is sometimes damaging.

FLAT PEA (*Lathyrus sylvestris*) was originally introduced into this country from central Europe. It is a long-lived perennial legume that spreads by rhizomes. The plants are especially succulent and have a high protein content. They furnish green feed late into the summer when grasses are usually dry. At Bellingham, Wash., on land-capability class IV as much as 5.2 tons per acre of dry matter are produced.

The primary conservation use of the flat pea is for erosion control on cut-over and burned-over areas of land-capability classes IV and VI in zones 1, 5, 12, and 16. These soils are low in fertility and establishment from seed is slow. Seedlings started in flats and transplanted to the field have given better stands and faster establishment than direct seeding. This method of planting is feasible on small areas because plants spaced 6 feet apart (1,210 plants per acre) give an excellent stand.

The use of flat pea is restricted in areas adjacent to commercial pea production because it is a host for the pea moth. There have been reports that flat pea may be toxic to some classes of livestock, particularly sheep. This has been tested and reported (*1*).

Perennial peavine (*Lathyrus latifolius*) is similar to flat pea. It is vigorous but is neither as palatable nor as high in yield as flat pea.

PERENNIAL VETCH (*Vicia tenuifolia*) is a highly variable sod-forming legume of foreign origin. Like common vetches it has narrow, smooth leaves and fine stems but spreads by rhizomes. It grows to 3 feet in height and has profuse purple blooms from June 15 to July 15. Its seeds are smaller than those of common vetch. They mature over a long period of time and, like other vetches, shatter readily. The strain in production at the Pullman, Wash., nursery is a selection from P. I. 107,128 (P–692). It is vigorous, productive, and early maturing It produces 150 to 300 pounds of seed per acre and must be cut by windrowing when the first seeds begin to shatter. Seeds are hard and must be scarified, and they should be inoculated before planting. Plants are slow to establish, reaching maturity in the third year. Stands are most successfully established on agricultural land by seeding in rows and cultivating for at least 1 year. Plants cultured in this way develop a dense erosion-control cover by the third season. This species appears useful on cut-over and burned-over timber areas as well as for a cover on road cuts and fills. Statistics for seed are given in table 1, appendix.

OTHER NATIVE AND FOREIGN LEGUMES which have been tested include 13 species of *Astragalus*, 2 each of *Hedysarum* and *Hosackia*, 19 of *Lathyrus*, 20 of *Lotus*, 28 of *Lupinus*, 9 of *Medicago*, 15 of *Onobrychis*, 36 of *Trifolium*, and 4 of *Trigonella*. Only a few of the species can be mentioned here.

Three introduced species of *Astragalus*—*A. davuricus*, *A. verus*, and *A. trantretteris*—were like *A. cicer* in all respects. *A. chinensis* is rapid developing and spreads by strong rhizomes, but production is low and the plant is short-lived. The native *A. arrectus* is promising, and *A. mortoni* contains promising strains. *A. rubyi* is tolerant of alkali but is hard-seeded and slow to

establish. *Swainsona salsula* is also tolerant of alkali and has vigorous rhizomes.

The dry-land perennial lupines *Lupinus rubicaulus, L. sericeus,* and *L. wyethii* are the easiest of the native species to grow. *L. littoralis* is a rapid-developing legume on coastal dunes but is short-lived and will not stand competition from grasses in mixtures. All these lupines shatter seed and volunteer. They are susceptible to injury from weevils and other insects.

Lathyrus littoralis can be used for dune control on the coast but *L. maritimus* is superior. *L. pratensis* and *L. tuberosus* are low-growing legumes that make good ground cover but produce less than *L. sylvestris.*

Siberian alfalfa (*Medicago falcata*) is prostrate and more drought-tolerant than the commercial alfalfa varieties but is low in production. *M. lupulina* is more drought-tolerant than alsike clover but has not shown promise for conservation uses. More than 15 species of *Onobrychis* have been tested. *O. vulgaris* (P. I. 109,327), a giant form of sainfoin, is very palatable, produces well, has a high seed yield, but is shorter lived than alfalfa. Six accessions of *Trigonella* have been tested, and none was superior to similar clovers in common use. Many species of *Trifolium* have been studied. *T. involucratum* is well adapted to low wet areas on coastal dunes, but seed is hard to grow. *T. macrocephalum* thrives on severely eroded residual soils to make a dense cover, but the seedlings are very weak and the plant requires several years to reach full production.

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Appendix

TABLE 1.—*Standards of seed quality and standard seeding rates for grasses and legumes used for soil and water conservation seedings in the Pacific Northwest. Data are based on laboratory tests, nursery trials, and field-scale plantings on farms in soil conservation districts*

Species	Seeds per pound [1]	Quality of seed			Weight per bushel	Rate of seeding per acre		
		Purity	Germination	Live pure seed		For seed [2]	When alone	In mixtures
	Number	*Percent*	*Percent*	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Agropyron cristatum	175,000	93	92	85	24	3 R	6	4
Agropyron dasystachyum	156,000	85	88	75	11	4 R	8	--------
Agropyron elongatum	79,000	92	90	83	16	4 R	8	--------
Agropyron inerme	135,000	92	90	83	18	4 R	8	8
Agropyron intermedium	100,000	94	90	85	22	5 R	--------	8
Agropyron riparium	170,000	96	95	91	22	----------	--------	6
Agropyron smithii	110,000	92	65	60	19	5 R	10	--------
Agropyron spicatum	140,000	94	90	85	20	4 R	8	8
Agropyron subsecundum	151,000	96	96	92	16	8 S	--------	8
Agropyron trachycaulum	160,000	94	92	86	19	8 S	--------	8
Agropyron trichophorum	91,000	90	91	82	20	4 R	10	8
Alopecurus arundinaceus and *A. pratensis* (natural)	900,000	72	76	55	10	2 R	--------	5
Alopecurus arundinaceus and *A. pratensis* (nude)	1,025,000	95	80	76	47	2 R	--------	5
Arrhenatherum elatius (d) [3]	130,000	92	87	80	10	3 R	--------	4
Bromus inermis	125,000	93	88	82	17	4 R	8	6
Bromus marginatus (d)	90,000	96	90	86	26	10 S	--------	10
Dactylis glomerata	488,000	90	90	81	17	3 R	--------	4
Elymus canadensis (d)	85,000	95	90	85	26	10 S	10	8
Elymus glaucus	131,000	96	88	84	26	8 S	8	--------
Elymus junceus	170,000	96	90	86	21	3 R	6	--------
Elymus triticoides	175,000	85	80	68	19	6 R	10	--------
Festuca elatior arundinacea	230,000	96	90	86	21	4 R	8	6
Festuca ovina	565,000	95	85	81	18	2 R	--------	4
Festuca rubra (creeping)	565,000	98	90	89	16	4 R	--------	4
Hordeum bulbosum (d)	46,000	90	87	78	38	12 S	--------	12
Lolium multiflorum	217,000	98	92	90	19	20 S	--------	2
Lolium perenne	247,000	95	94	89	20	20 S	--------	3
Oryzopsis hymenoides (P–2575)	235,000	99	38	38	50	8 R	15	--------
Phalaris arundinacea	506,000	98	75	74	34	4 R	8	--------
Phleum pratense	1,319,000	98	87	85	45	3 S	--------	3
Poa ampla	917,000	85	72	61	16	3 R	6	4
Astragalus cicer	145,000	95	15+60	71	65	10 R	--------	15
Astragalus falcatus	97,000	98	14+76	88	65	10 R	--------	12
Lotus corniculatus	470,000	94	75+18	87	63	2 R	--------	4
Lotus uliginosus	1,092,000	98	60+22	80	62	1 S	--------	2
Melilotus alba	262,000	98	70+20	88	62	2 R	10	5
Trifolium subterraneum—Mt. Barker	75,000	98	65+25	88	-------	6 S	--------	4
Trifolium subterraneum—Tallarook	52,000	98	65+25	88	61	8 S	--------	5
Vicia tenuifolia	33,000	99	31+57	87	58	8 R	--------	15

[1] Values are averages of many lots; normal variation ±15 percent.
[2] R=Rows 36 to 42 inches; S=Solid drills.
[3] Deawned.

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